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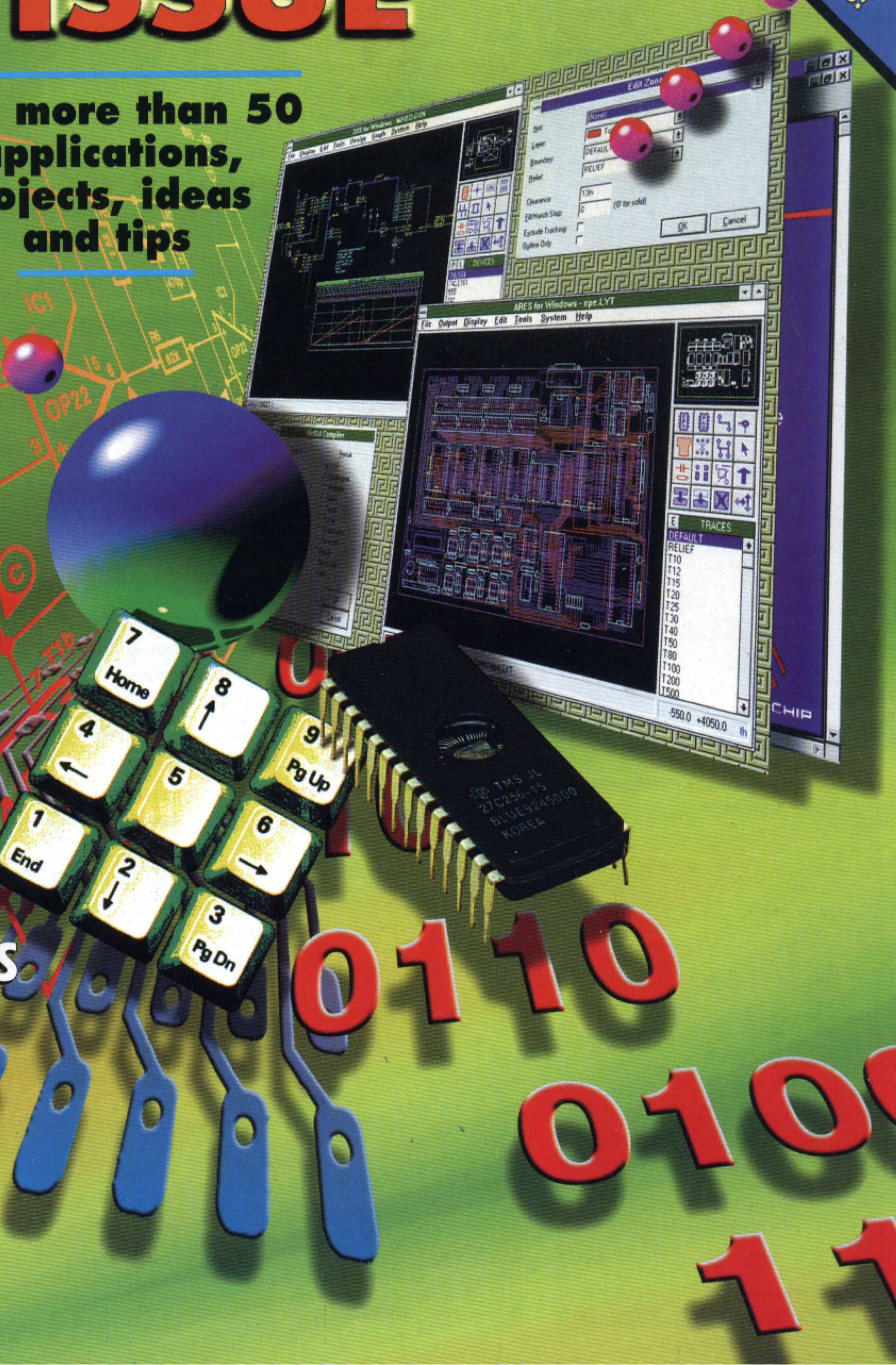

COPYBIT KILLER

INFRA-RED RC EXTENSION

DEVELOPMENTS IN BATTERY CHARGERS

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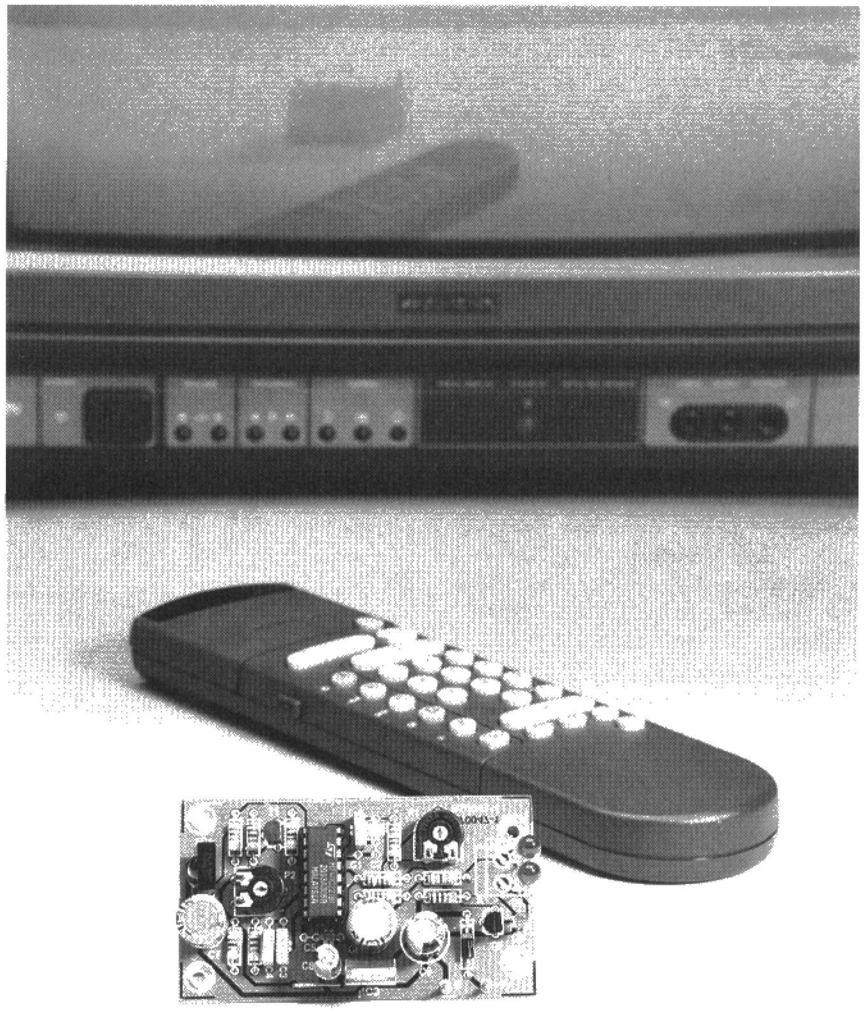
RC5 remote control extension



Over the years, infra-red remote control units have become better designed and more reliable. They retain a few weak facilities, however, owing to the laws of nature. Their range is fairly limited and there needs to be a straight and clear line of sight between receiver and controller. These weaknesses may be obviated with the extension unit described in this article, which has been designed primarily for use with Type RC5 remote controllers.

Design by T. Giesberts

INTRODUCTION

All of us, at least in the western world, live in a *zap** culture. We are so used to infra-red remote control of our television receiver and audio system, that few of us will now get out of our easy chair to change channel, colour, or volume. With a cup of coffee, tea or chocolate in one hand and the remote controller in the other we flick through TV or FM channels and feel like rulers of our own audio visual empire.

Unfortunately, Mother Nature sometimes spoils this feeling of power, for instance when, in an L-shaped room the infra-red transmission from the controller steadfastly refuses to go around a corner to change the volume, contrast, or what have you. And, of course, infra-red control of the audio installation from one room to another is completely impossible.

This sort of problem can be solved in three ways: (1) move the equipment so that there is again a clear line of sight between it and the controller; (2) remove the obstacle between the equipment and controller (not always possible in case of walls), or (3) use a repeater unit like the one described placed at a strategic spot. This repeater receives the signal from the controller and passes it on to the relevant equipment..

** a slang word, first used in this sense in the mid 1980s, meaning to move quickly through the commercial break on a recorded video tape either by using the fast-forward facility or by switching through live channels.*

INFRA-RED (IR) TRANSMITTER/ RECEIVER

The repeater consists in essence of a complete transmitter/receiver for RC5-coded infra-red signals. The signals transmitted by the controller are received and demodulated with the aid of an integrated infra-red receiver. The decoded pulses are then superimposed on to a new 36 kHz carrier with the aid of two monostable multivibrators (MMVs). The carrier so modulated is transmitted by two infra-red light-emitting diodes (LEDs).

The extension is constructed as a small unit that is to be placed in such a position that its receiver has a clear line of sight to the controller and its emitter one to the equipment to be operated.

CIRCUIT DESCRIPTION

From the circuit diagram in **Figure 1**, it is clear that the extension unit is a straightforward small design.

As far as the receiver section is concerned, the photodiode that functions as the infra-red receptor is contained, together with the requisite amplifier and demodulation circuits, in IC_1. This IC is specially designed for the processing of 36 kHz signals associated with an RC5 controller.

The active-low output pulses of IC_1 are re-modulated by IC_2. This device contains two monostable multivibrators (MMVs) of which one determines the width and the other the spacing of the output pulses.

The multivibrators may also be triggered by a high logic level at the reset input of IC_2, provided that both trigger inputs are enabled (A low, and B high). This facility enables a pulse to be generated immediately following the leading edge of the first output pulse from receiver circuit, IC_1.

As the reset input of IC_{2a}, pin 3, is active low, an inverter is needed to trigger this multivibrator during the active periods of IC_1. So as not to complicate matters, a standard transistor, T_1, is used for this. Fortunately, IC_1 can do with a pull-up resistor. The values of resistors R_1 and R_2 ensure that T_1 changes state when the potential across R_1 is 2.5 V. The tiny delay introduced by T_1 is sufficient to ensure that the leading edge of the reset pulse arrives at IC_{2A} after trigger input A has been enabled. If this were not so, the edge of the reset pulse would be missed, causing the circuit to remain inactive since there would be no initial pulse to start IC_{2B}.

The output of IC_{2A} is applied to trigger input A of IC_{2B}. The output of this second multivibrator in turn triggers IC_{2A} via its B trigger input. In this way, IC_{2B} determines the pulse spacing. The ratio of the widths of the output pulses of IC_{2a} and IC_{2B} is 1:2.

Parallel-connected capacitors C_3 and C_4 have the same value as C_1.

The pulse duration of the two multivibrators may be varied over a range of roughly ±20 per cent with P_1 and P_2 respectively. Normally, it will suffice to set these presets to their centre position. If, however, the range of P_1 is found inadequate, it may be stretched to some extent by changing the values of C_1 and C_2. This would be a rare instance, however.

The output pulses of IC_{2A} are used to turn on the two series-connected infra-red diodes via transistor T_2. These diodes may be mounted on the printed-circuit board or they may be mounted at a distanced and linked to the board via suitable lengths of cable.

Power for the extension unit may be derived from a standard 9 V mains adaptor. The supply voltage is regulated by IC_3. The extension unit draws a quiescent current of a few milliamperes, but this rises to about 20 mA when RC5 data are being emitted. Diode D_3 functions as the on/off indicator.

1

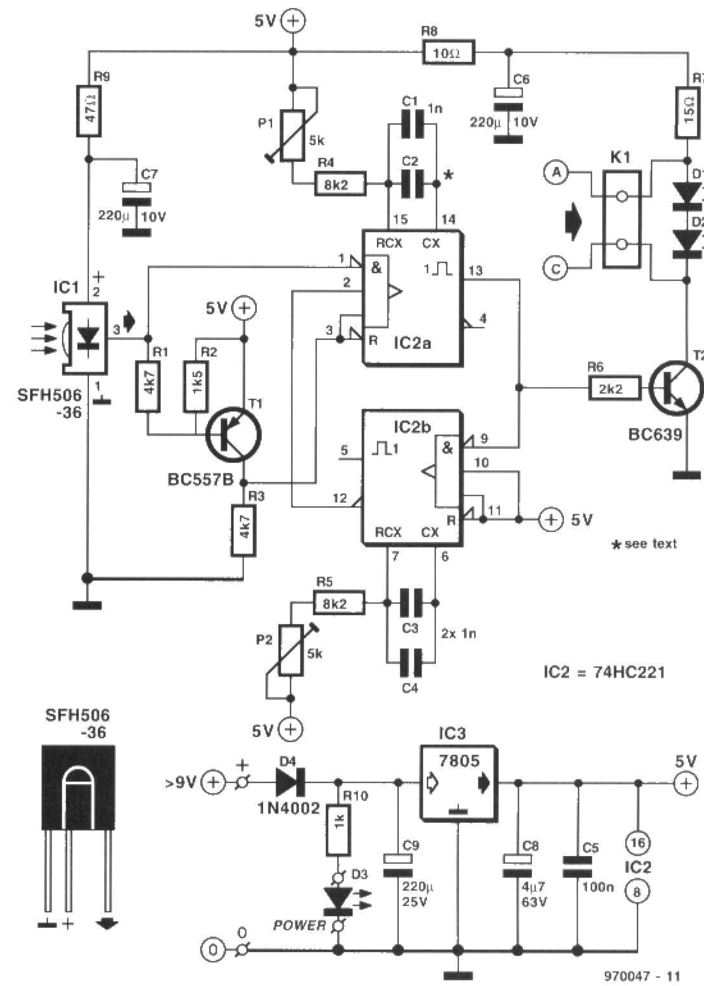


Figure 1. The circuit diagram of the extension unit. The circuit is based on an integrated receptor/demodulator and two monostable multivibrators.

CONSTRUCTION

The extension unit is best constructed on the printed-circuit board shown in **Figure 2**. The work is straightforward and should not take more than an hour or so.

Care should be taken that circuit IC_1 cannot receive the data emitted by D_1 and D_2 to avoid a kind of optical 'ringing' effect.

The unit should be housed in a suitable plastic (ABS) case measuring roughly 100 × 50 × 40 mm, in which windows must be cut (drilled) to give IC_1, and D_1 and D_2, access to the outside world. This cutting (drilling) may be avoided if a transparent or translucent case is used, but these are not always readily available.

Whether D_1 and D_2 are mounted on the board, or connected to it by a short cable (via K_1) is a matter of personal choice or preference. Normally, a cable, if used, should not need to be longer than one metre (three feet).

FINALLY ...

The efforts to keep the design as sim-

2

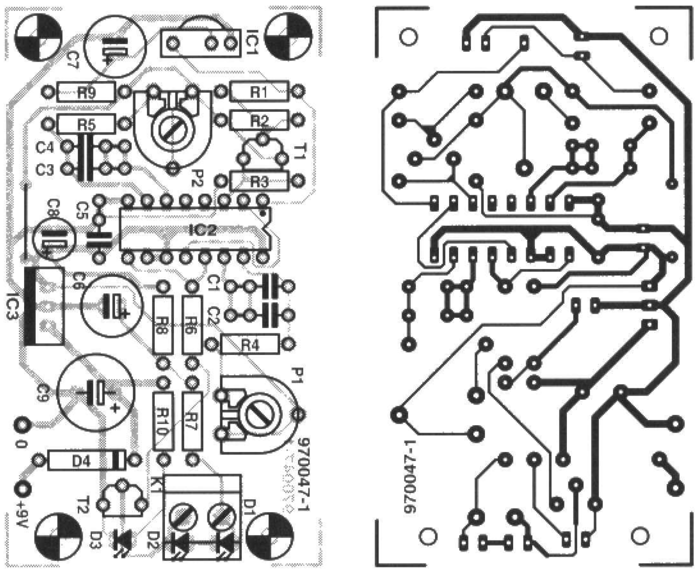


Figure 2. Printed-circuit board for the extension unit.

ple as possible have resulted in a slight drawback, which, in practical use with the prototype, has proved to be innocuous, however. It concerns the width of the output pulses of IC_1, which exceeds that of the pulses contained in the pulse train emitted by the RC5 controller. Consequently, because of the way these pulses are re-modulated, the 36 kHz pulse trains at the output of the extension unit contain a few more pulses than the original signal. It is fairly certain that this may cause a problem only when two extension units are used in cascade – a rare case, indeed.

[970047]

Parts list

Resistors:
R_1, R_3 = 4.7 kΩ
R_2 = 1.5 kΩ
R_4, R_5 = 8.2 kΩ
R_6 = 2.2 kΩ
R_7 = 15 Ω
R_8 = 10 Ω
R_9 = 47 Ω
R_{10} = 1 kΩ
P_1, P_2 = 4.7 kΩ (5 kΩ) preset

Capacitors:
C_1, C_3, C_4 = 0.001 μF
C_2 = not used
C_5 = 0.1 μF
C_6, C_7 = 220 μF, 10 V, radial
C_8 = 4.7 μF, 63 V, radial
C_9 = 220 μF, 25 V, radial

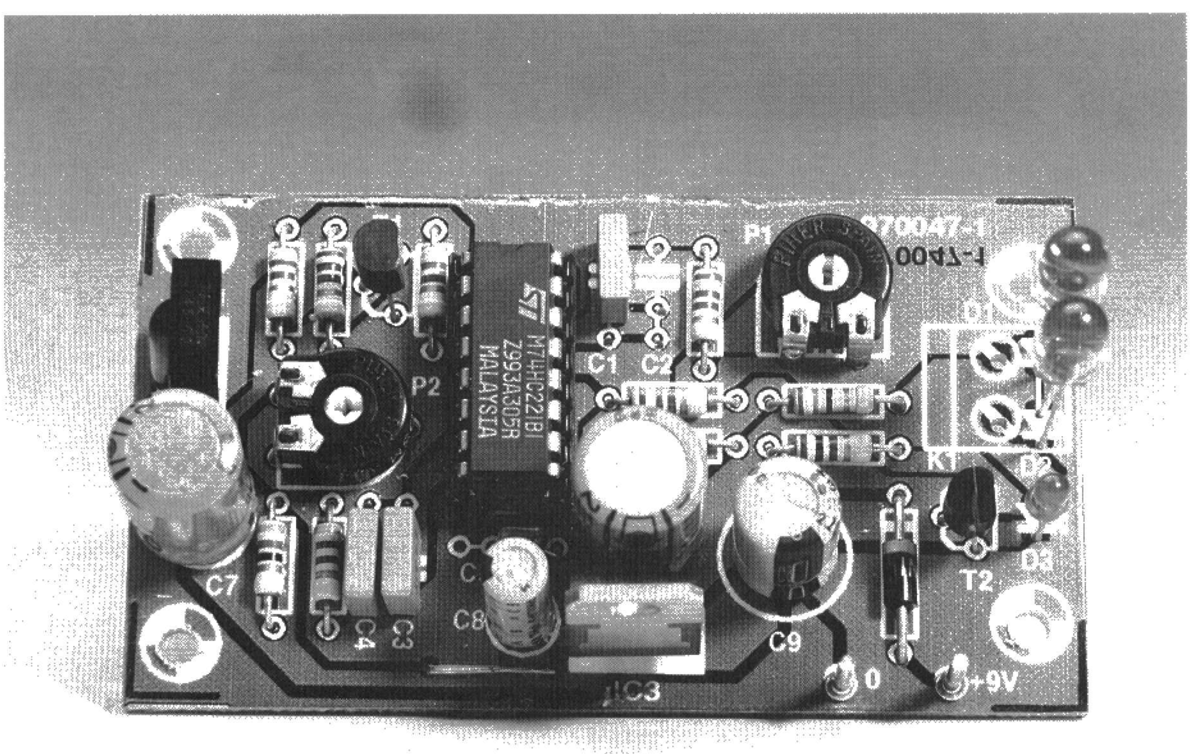
Semiconductors:
D_1, D_2 = infra-red diode, e.g., LD271 or LD274
D_3 = LED, high efficiency
D_4 = 1N4002
T_1 = BC557B
T_2 = BC639

Integrated circuits:
IC_1 = SFH506-36 (Siemens)
IC_2 = 74HC221
IC_3 = 7805

Miscellaneous:
K_1 = two-way terminal block, pitch 5 mm
Enclosure 100×50×40 mm
PCB Order no 970047-1 (see Readers Services section elsewhere in this issue)

Figure 3. Prototype of the extension unit. Note that the infra-red diodes are not mounted on the board, but connected to it via a short cable and K_1.

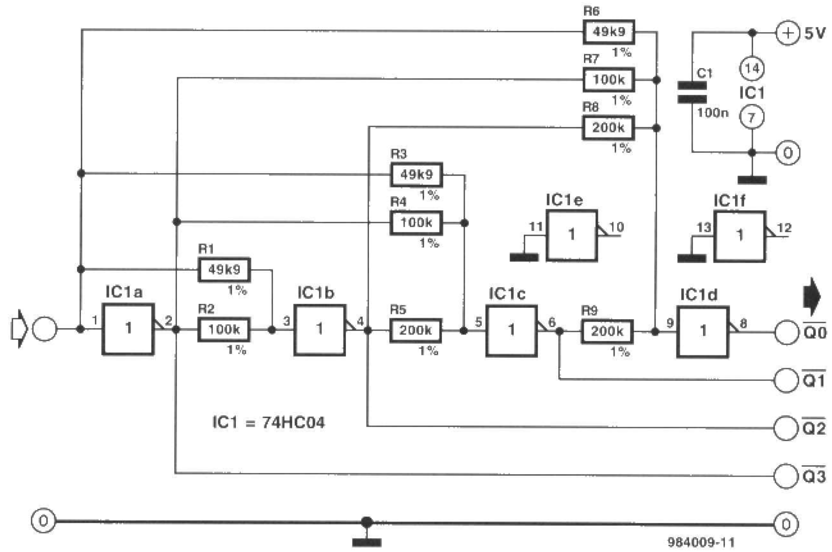
3



001

4-bit analogue-to-digital converter

Design: G. Baars



The operation of the converter is based on the weighted adding and transferring of the analogue input levels and the digital output levels. It consists of comparators and resistors. In theory, the number of bits is unlimited, but each bit needs a comparator and several coupling resistors. The diagram shows a 4-bit version.

The value of the resistors must meet the following criteria:

$R_1:R_2 = 1:2;$
$R_3:R_4:R_5 = 1:2:4;$
$R_6:R_7:R_8:R_9 = 1:2:4:8.$

The linearity of the converter depends on the degree of precision of the value of the resistors with respect to the resolution of the converter, and on the accuracy of the threshold voltage of the comparators. This threshold level must be equal, or nearly so, to half the supply voltage. Moreover, the comparators must have as low an output resistance as possible and as high an input resistance with respect to the load resistors as feasible. Any deviation from these requirements affects the linearity of the converter adversely. If the value of the resistors is not too low, the use of inverters with an FET (field-effect transistor) input leads to a near-ideal situation.

In the present converter, complementary metal-oxide semiconductor (CMOS) inverters are used, which, in spite of their low gain, give a reasonably good performance.

If standard comparators are used, take into account the output voltage range and make sure that the potential at their non-inverting inputs is set to half the supply voltage.

If high accuracy is a must, comparators Type TLC3074 or similar should be used. This type has a totem-pole output. The non-inverting inputs should be interlinked and connected to the tap of a a divider consisting of two 10 kΩ resistors across the supply lines.

It is essential that the converter is driven by a low-resistance source. If necessary, this can be arranged via a suitable op amp input buffer.

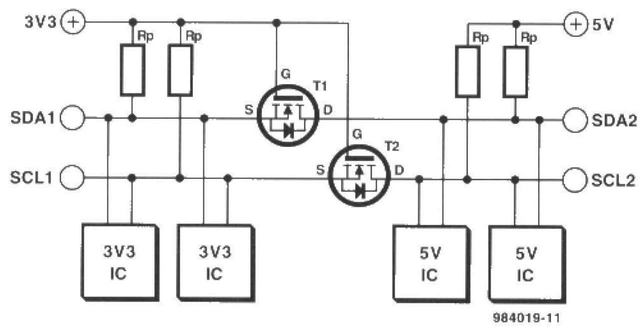
The converter draws a current not exceeding 5 mA.

[984009]

002

bi-directional I²C level shifter

Philips Semiconductor Application



The advantages and ease of use of an I²C link are well known. Since its introduction almost 20 years ago, it has been applied in more than 1000 types of IC. All these ICs are designed for operation from a 5 V power supply. However, more and more ICs coming on to the market use a 3.3 V supply. The bi-directional shifter described in this application note is intended to interconnect two sections of an I²C-bus system, each section with a different supply voltage and different logic levels. In the bus system in the diagram, the left section has pull-up resistors and devices connected to a 3.3 V supply voltage, whereas the right section has pull-up resistors and devices connected to a 5 V supply voltage. The devices of each section have I/Os with supply voltage related logic input levels and an open drain output configuration.

The level shifters for each bus line are identical and consist of one discrete n-channel enhancement MOSFET, T_1, for the serial data line, SDA, and T_2 for the serial clock, SCL. The gates (g) have to be connected to the lowest supply voltage, V_{DD1}, the sources (s) to the bus lines of the lower voltage section, and the drains (d) to the bus lines of the higher voltage section. Many MOSFETs have the substrate internally already connected with the source; if not, it should be done externally. The diode between the drain and substrate is inside the MOSFET and represents the n-p junction of drain and substrate.

Three situations may arise.

1. The bus is not used and is,

therefore, not made low by one of the ICs. The gate and source are both at 3.3 V so that the transistor is cut off. The I²C bus at the right section is not affected and this line is also high, but here the high level is 5 V (in the left section, it is 3.3 V).

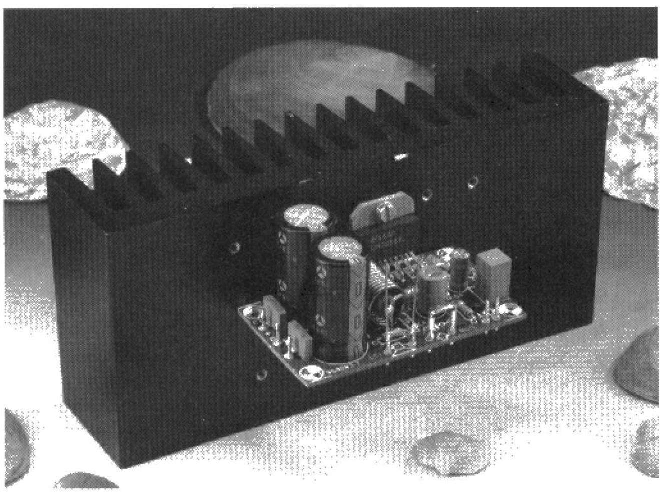
2. An IC in the left section makes the bus low. The level at the source of the transistor is 0 V and that at the gate, 3.3 V. The transistor conducts, so that the 5 V section is pulled low by the transistor and the relevant IC. This means that the low level at the left section is transferred to the right section.

3. An IC in the right section makes the bus low. The left section is pulled low via the diode in the transistor, not necessarily to zero but to a level a diode voltage above zero. This level is, however, low enough to switch on the transistor, since the potential at the source is a few volts below that at the gate. Since FETs can conduct in two directions, the left section is made low via the transistor and the relevant IC in the right section. So, again the low level is transferred.

It is obvious that the FETs used must have some specific properties. One of the most important of these is that the transistor must conduct when the gate-source potential is less than 2 V. Also, its channel resistance must be lower than 100 Ω, and it must be able to carry a current of at least 10 mA. Its input capacitance should not exceed 100 pF and it should be capable of switching within 5 ms. Suitable Philips types are the BSN10, BSN20, BSS83, and BSS88.

[984019]

003 100-watt single-IC amplifier



Specifications *(8 Ω/1 kHz unless otherwise noted)*

Input sensitivity:	*1 V_{rms} (63 W into 8 Ω)*
Output power, 8 Ω:	*63 W (THD <1%)*
Output power, 4 Ω:	*108 W (THD <1%)*
Damping factor (8 Ω)	*>450 at 1 kHz* *>170 at 20 kHz*
Slew rate:	*>10 V/μs (rise time = 5 μs)*
Power bandwidth:	*8 Hz to 90 kHz*
Signal/noise ratio:	*94 dBA (1 W into 8 Ω)*

Design: T. Giesberts

According to National Semiconductor, the LM3886 is a high-performance 150W Audio Power Amplifier with Mute. The performance of the LM3886, say NS, utilising its Self Peak Instantaneous Temperature (°Ke) (SPIKe) protection circuitry, puts in a class above discrete and hybrid amplifiers by providing an inherently, dynamically protected Safe Operating Area (SOA). The LM3886T comes in an 11 (staggered-) lead non-isolated TO220 package.

We put the LM3886T through its paces, using two earlier publications (Ref. 1, 2) and an existing printed circuit board as a basis. For test purposes, the prototype of the amplifier was powered by a stabilised ±35-V supply. A maximum undistorted output power of about 63 watts into 8 ohms was obtained at a drive level of 1 Vrms. Dropping the load impedance to 4 ohms pushed the output power to no less then 108 watts. In practice, these power levels can be taken to mean 'music power', but do remember that the amplifier will not normally be powered from a regulated supply!

Great attention should be paid to the cooling of the amplifier IC. The cooling capacity offered by a heatsink as specified in the parts list is really only sufficient for load impedances of 6 ohms or more. Even if a heatsink with a thermal resistance lower than 1 K/W is employed, the amplifier IC will cause a 'hot spot' on the heatsink surface where the actual thermal resistance is much higher locally than the specification! With this in mind, it is recommended to drop the supply voltage to about ±30 V if the amplifier is used to drive a 4-ohm load. Also, bear in mind that heatsink isolating materials like mica and even ceramics tend to raise the thermal resistance by 0.2 K/W to 0.4 K/W. The metal tab at the back of the IC is at the negative supply potential.

Boucherot network C6-R6 is not normally required in this application, and should be omitted unless the amplifier is found to be unstable as a result of an application which is widely different from the one shown here.

Populating the amplifier board itself will be a piece of cake, and most of the time required to build the amplifier will go into drilling, cutting, mounting and isolating the heatsink. The printed circuit board shown here is available ready-made through the Publishers' Readers Services. Note that the radial electrolytic capacitors are rated at 40 volts, so you have to make sure that the supply voltage can never exceed that level. The performance of the prototype amplifier built and tested in our design lab is expressed by the Specifications box.

(984062-1)

COMPONENTS LIST

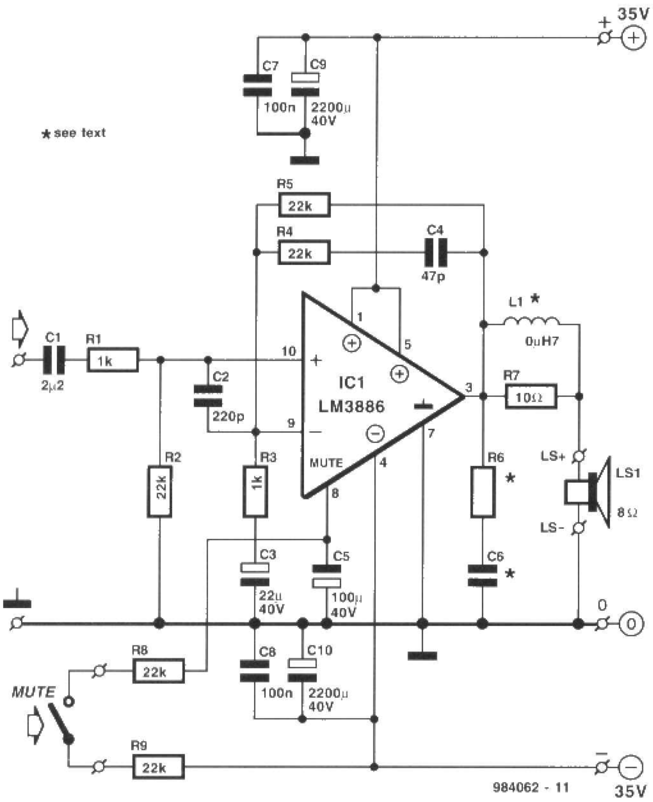
Resistors:
R1,R3 = 1kΩ
R2,R4,R5,R8,R9 = 22kΩ
R6 = not fitted, see text
R7 = 10Ω, 5W

Capacitors:
C1 = 2μF2, MKT (Siemens), pitch 5mm or 7.5mm
C2 = 220pF, 160V, axial, polystyrene (Siemens)
C3 = 22μF, 40V, radial
C4 = 47pF, 160V, axial, polystyrene (Siemens)
C5 = 100μF, 40V, radial
C6 = not fitted, see text
C7,C8 = 100nF
C9,C10 = 2200μF, 40V, radial, max. diameter 16mm

Inductor:
L1 = 0.7μH, 13 turns of 1.2-mm diameter (#18 SWG) enamelled copper wire, 10mm internal diameter, wound around R7.

Semiconductor:
IC1 = LM3886T (National Semiconductor)

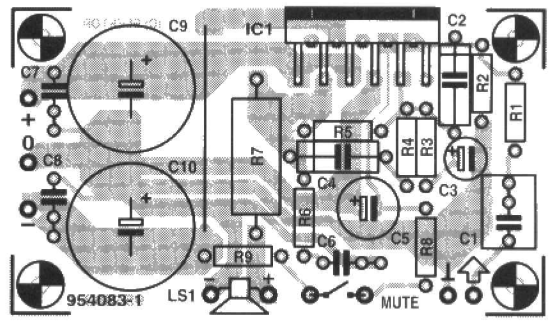
Miscellaneous:
Heatsink for IC1: specification R_{th} < 1K/W
Printed circuit board, order code 954083-1.

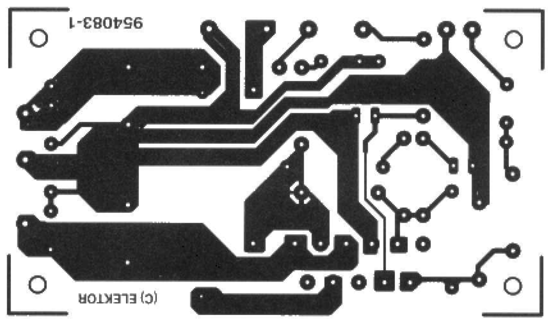


References:

1. LM3886 150W Audio Power Amplifier with Mute (Application Note), *Elektor Electronics* May 1995.

2. Single-chip 50 W AF Amplifier, *Elektor Electronics* December 1995.





004 thrifty voltage regulator

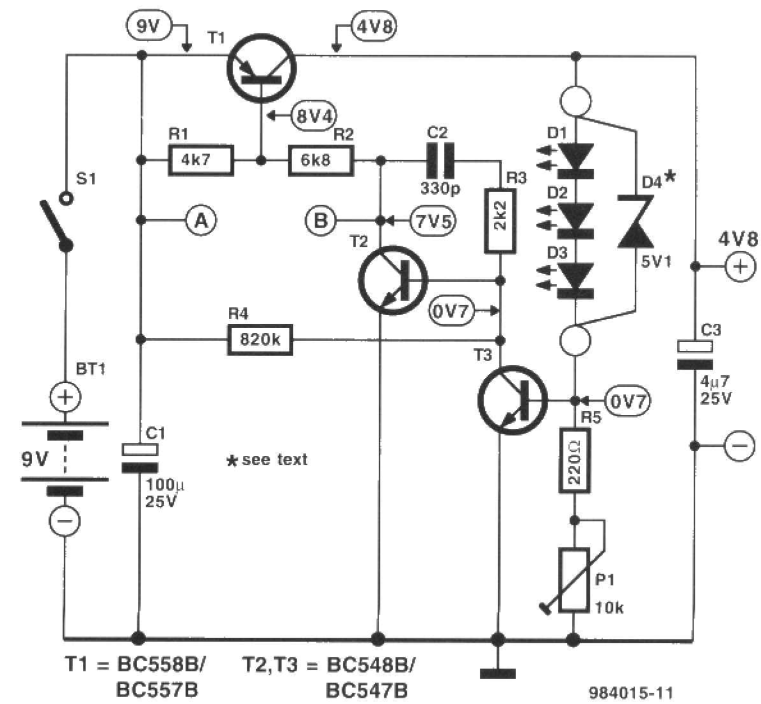
Design: F. Hueber

One of the drawbacks of a three-pin voltage regulator is that the input voltage needs to be 2.5–3 V higher than the output voltage. This makes these integrated regulators unsuitable for battery power supplies. If, for instance, the output voltage is 5 V, a 9 V battery could be discharged to 7.5 V or thereabouts only. On top of this, most of these regulators draw a current of about 2 mA. Special low-drop versions sometimes offer a solution, but they are not ideal either.

The regulator described here is rather thriftier: it draws a current of only 300 µA and the difference between its input and output is only 100–200 mV

In the circuit diagram, T_1 is arranged as a series regulator, which means that the difference between input voltage and output voltage is limited to the transistor's saturation potential. Therefore, a 9 V battery can be discharged to about 5 V, which is quite an improvement on the situation with an integrated regulator.

1



Diodes D_1-D_2-D_3, or a suitable zener diode (D_4), in conjunction with R_5 and P_1, form a variable reference voltage source, which is used as the (output-dependent) base potential of T_3. If the output voltage drops below a desired level, the base potential of T_3 also drops. The transistor then conducts less hard and its collector volt-

age rises. The base voltage of T_2 also rises, so that T_1 is driven harder. This results in the near-instantaneous restoration of the output voltage.

The design of the reference voltage source is clearly of paramount importance. The current through the LEDs or the zener diode is of the order of only 100 μA. This means that the drop across a 5.1 V zener diode is only 4.3 V and across each LED, only about 1.43 V. For a wanted output voltage of 4.8 V, the three LEDs proved very effective, whereas the zener did not. It may well be necessary, if a zener diode is used, to try one rated at 4.7 V. If, however, an output voltage of 5 V is wanted, it will be necessary to carefully select a zener diode.

When the battery voltage has dropped to a level where it is only marginally higher than the wanted output voltage, T_1 and T_2 conduct hard. A further drop in the battery voltage will cause the collector potential of T_2 to drop rapidly to 0 V, since T_2 tries to make T_1 conduct hard.

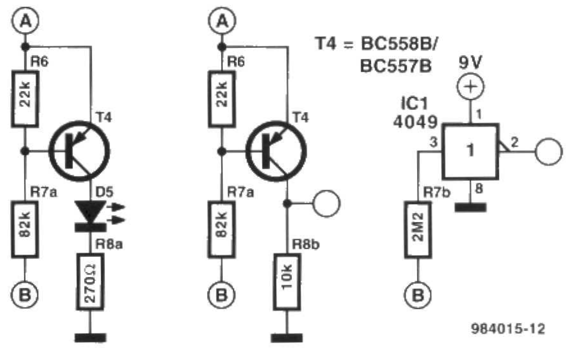
The large drop in the collector potential of T_2 may be used to drive a BATT-LOW indicator. This may be done in three ways as shown in **Figure 2**.

When network a is connected between terminals A and B, transistor T_4 will normally be held cut off by divider R_6-R_{7a}. If then the voltage at B drops suddenly, T_4 conducts, whereupon D_5 indicates that the battery is nearly flat.

The network in b is similar to that in a, but is intended for a liquid-crystal display of BATT LOW. The collector of T_4 is linked to the IC that drives the decimal point and the BAT-LOW segment of the display.

Network c may be used if there is an unused inverter or gate in the circuit to be powered. The high value of resistor R_{7b} prevents the internal protection diodes of the IC being damaged.

2



When the regulator has been built, connect it to a variable power supply via a multimeter set to the mA range and set P_1 roughly at its mid-position. Turn P_1 slowly until the desired output voltage is obtained.

If with an output voltage of 4.8 V the regulator draws a current of more than 250–300 μA, the three LEDs or zener diode must be replaced.

The regulator can provide a current of up to about 25 mA. With a fresh 9 V battery, the dissipation of T_1 does not exceed 100 mW. If the input voltage is higher, it may be necessary to mount the transistor on a suitable heat sink or replace it by a power transistor, for instance, a Type BD138.

[985015]

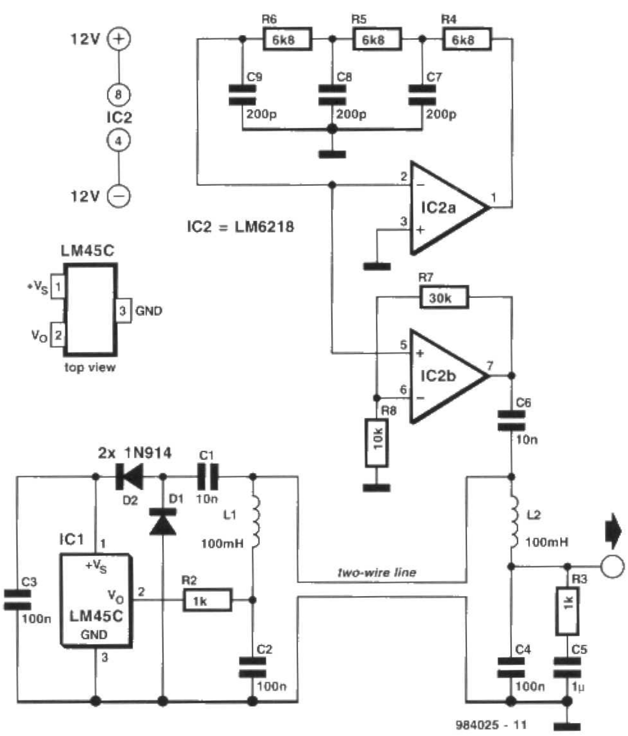
005 two-wire temperature sensor

National Semiconductor application

Remote temperature measurements have to be linked by some sort of cable to the relevant test instrument. Normally, this is a three-core cable: one core for the signal and the other two for the supply lines. If the link is required to be a two-core cable, one of the supply lines and the signal line have to be combined. This is possible with, for instance, temperature sensors LM334 and LM335. However, these devices provide an output that is directly proportional to absolute temperature and this is not always a practical proposition.

If an output signal that is directly proportional to the celsius temperature scale is desired, the present circuit, which uses a Type LM45 sensor, offers a good solution. The LM45 sensor is powered by an alternating voltage, while its output is a direct voltage.

The supply to the sensor is provided by a sine-wave generator, based on A_1 and A_2 (see diagram). The alternating voltage is applied to the signal line in the two-core cable via coupling capacitor C_6.



The sensor contains a voltage-doubling rectifier formed by D_1-D_2-C_1-C_2. This network converts the applied alternating voltage into a direct voltage. Resistor R_2 isolates the output from the load capacitance, while choke L_1 couples the output signal of the sensor to the signal line in the cable. Choke L_1 and capacitor C_2 protect the output against the alternating voltage present on the line.

At the other end of the link, network R_3-L_2-C_4 forms a low-pass section that prevents the alternating supply voltage from combining with the sensor output. Capacitor C_5 prevents a direct current through R_3, since this would attenuate the temperature-dependent voltage.

The output load should have a high resistance, some 100 kΩ or even higher.

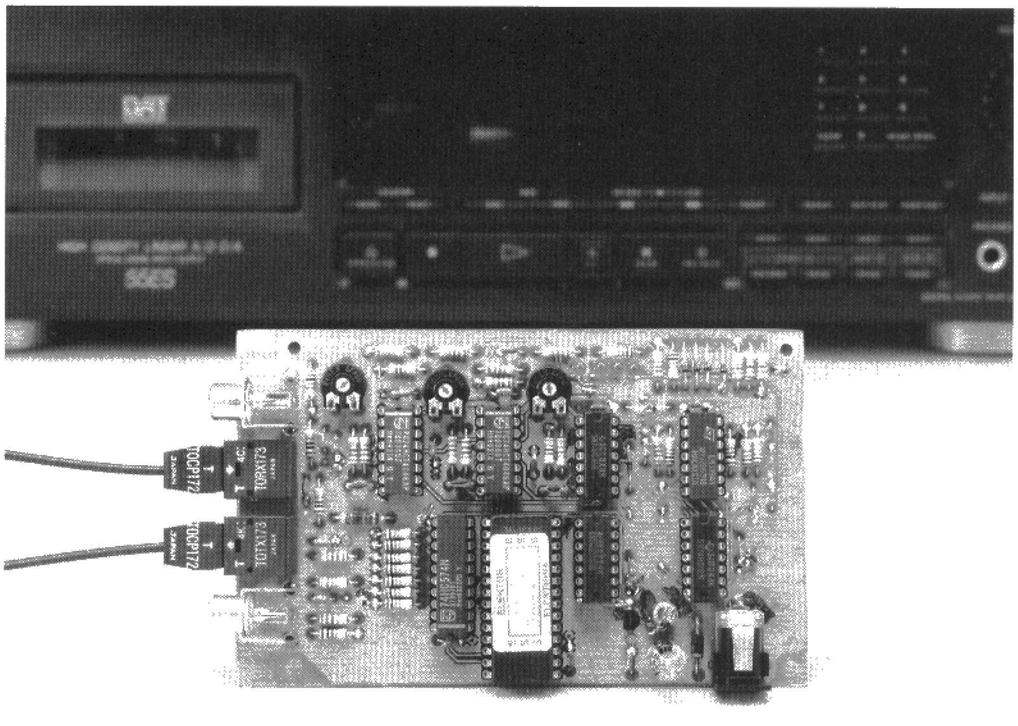
The circuit draws a current of a few mA.

[984025]

simple copybit killer

enables limitless digital copying

The Serial Copy Management System (SCMS) prevents digital copying of audio material from the second generation onwards. Unfortunately, this protection also works on home recordings and so prevents home recordists from digitally copying their own musical work more than once without degradation by the SCMS. This problem has been highlighted before in this magazine, but it has not gone away – reason enough to describe a simple and inexpensive circuit for permanently removing the copy-prohibit-bit from the S/PDIF* audio signal.



Design by H. Hanft

GENERAL DESCRIPTION

The circuit described in this article is intended for the digital recording or copying and playback of non-commercial musical work. Such recording or copying is possible only when the copy-prohibit has been eliminated without any other effect on the audio signal.

The design of the circuit is such that there are no modifications required in the existing audio installation. The circuit is simply inserted in series with the digital (optical or coaxial) link between the relevant recording and playback equipment.

Briefly, the circuit:

- requires no modification to the digital audio equipment;
- is suitable for use with signals on optical as well as coaxial lines;
- uses readily available components;
- operates without programmable ICs such as PALs and EPLDs;
- is easily set up;
- has good clock regeneration through the use of PLLs (jitterkiller);
- gives clear indication (LEDs) of the sampling frequency (32 kHz, 44.1 kHz, or 48 kHz);
- automatically recognizes, and switches over to, the correct sampling frequency;
- draws a small current owing to the use of CMOS ICs.

CIRCUIT DESCRIPTION

The block diagram of the copybit killer is shown in **Figure 1**. It shows that the copybit killer consists of:

- optical-to-electrical convertor for the S/PDIF signals;
- differentiating network;
- phase-locked loop (PLL) to regenerate the clock frequency;
- network for recognizing and processing the clock frequency;
- network for recognizing and dis-

** Sony/Philips Digital Interface Format – the consumer version of the AES/EBU standard. This standard was devised by the American Audio Engineering Society and the European Broadcasting Union to define the signal format, electrical characteristics, and connectors, to be used for digital interfaces between professional audio products.*

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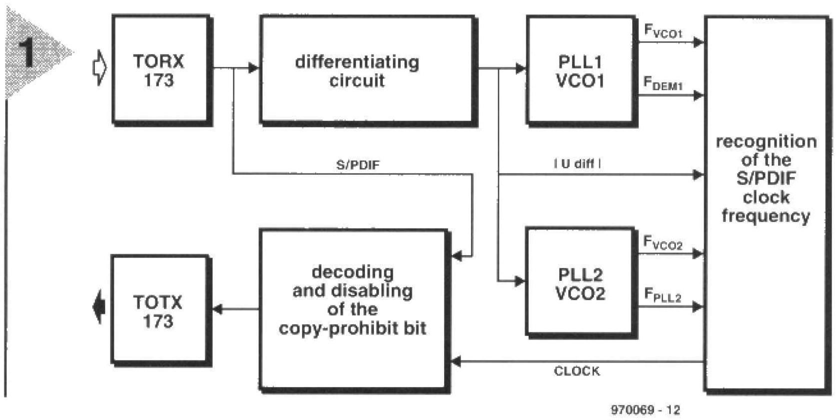


Figure 1. Block diagram of the copybit killer. The core of the circuit, 'decoding and disabling of the copy-prohibit-bit', uses an EPROM.

abling the copy-prohibit-bit;
- electrical-to-optical convertor for the S/PDIF signals.

The circuit diagram proper is shown in **Figure 2**. The operation of the various networks outlined above is described in the following sections.

The **optical-to-electrical conversion of the S/PDIF signal** is carried out by IC_1, which is the well-known Type TORX173 integrated receiver. It converts the signal input from the fibreglass cable into an electrical signal at TTL level. There is, of course, also a facility for inputting signals from a standard coaxial cable. This is possible via audio connector K_1 in parallel with the output of IC_1 via resistor R_2.

The **differentiating circuit**, consisting of XOR gates IC_{2a}–IC_{2c} and *RC* networks R_5-C_3 and R_6-C_4, serves to detect the rising or falling edges of the incoming S/PDIF signal. For each and every edge, a positive pulse of defined length is generated and used for synchronizing the following PLL.

The regeneration of the clock frequency contained in the S/PDIF signal is carried out by two discrete **phase-locked loops** (PLLs). The first one is for frequencies 6.144 MHz (sampling rate 48 kHz) and 5.6448 MHz (sampling frequency 44.1 kHz), and the second for frequency 4.096 MHz (sampling frequency 32 kHz)

So as to keep the circuit simple, both PLLs are Type 74HCT4046 ICs (IC_3 and IC_4). These circuits contain not only a phase comparator, but also a voltage-controlled oscillator (VCO). The PLLs circuits are virtually identical and differ only as far as the value of the resistor that sets the central frequency of the VCO is concerned (R_7 and R_{10}).

The network for **recognizing the clock frequency** serves to detect the sampling frequency of the S/PDIF signal and pass this on to the decoder. It consists of IC_{5a}–IC_{5d} and four NOR gates, IC_{6a}–IC_{6d}. The comparators recognize the incoming S/PDIF signal and ensure that the PLL locked in at that moment is included in the sigal processing. Also, when the sampling frequency is 48 kHz or 44.1 kHz, the VCO control

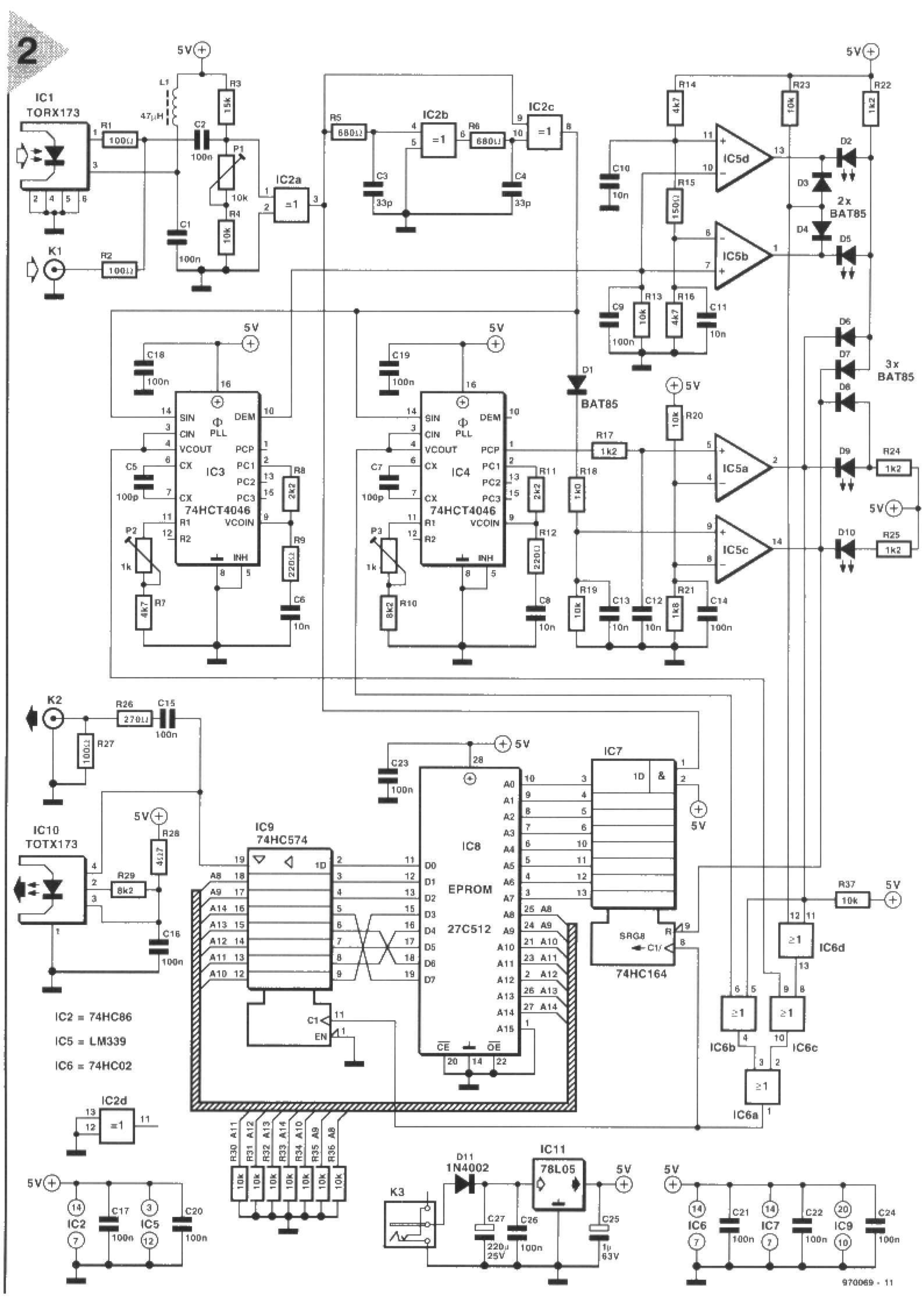


Figure 2. Circuit diagram of the copybit killer. All components are readily available and the circuit is easy to build and set up.

3

Parts list

Resistors:
R_1, R_2, R_{27} = 100 Ω
R_3 = 15 kΩ
R_4, R_{13}, R_{19}, R_{29}, R_{23}, R_{30}–R_{37} = 10 kΩ
R_5, R_6 = 680 Ω
R_7, R_{14}, R_{16} = 4.7 kΩ
R_8, R_{11} = 2.2 kΩ
R_9, R_{12} = 220 Ω
R_{10}, R_{29} = 8.2 kΩ
R_{15} = 150 Ω
R_{17}, R_{22}, R_{24}, R_{25} = 1.2 kΩ
R_{18} = 1.0 kΩ
R_{21} = 1.8 kΩ
R_{26} = 270 Ω
R_{28} = 4.7 Ω
P_1 = 10 kΩ preset potentiometer
P_2, P_3 = 1 kΩ preset potentiometer

Capacitors:
C_1, C_2, C_9, C_{14}–C_{24}, C_{26} = 0.1 μF, ceramic
C_3, C_4 = 33 pF
C_5, C_7 = 100 pF
C_6, C_8, C_{10}–C_{13} = 0.01 μF
C_{25} = 1 μF, 63 V, radial
C_{27} = 220 μF, 25 V, radial

Inductors:
L_1 = 47 μH

Semiconductors:
D_1, D_3, D_4, D_6–D_8 = BAT85
D_2, D_5, D_9, D_{10} = LED, high efficiency
D_{11} = 1N4002

Integrated circuits:
IC_1 = TORX173
IC_2 = 74HC86
IC_3, IC_4 = 74HCT4046
IC_5 = LM339
IC_6 = 74HC02
IC_7 = 74HC164
IC_8 = 27C512 (available ready programmed: Order no 976516* – see Readers Services towards the end of this issue)
IC_9 = 74HC574
IC_{10} = TOTX173
IC_{11} = 78L05

Miscellaneous:
K_1, K_2 = audio socket for PCB
K_3 = mains adaptor socket for PCB
PCB Order no. 970069* – see Readers Services towards the end of this issue

* These items may be purchased as a combination: Order no. 970069-C

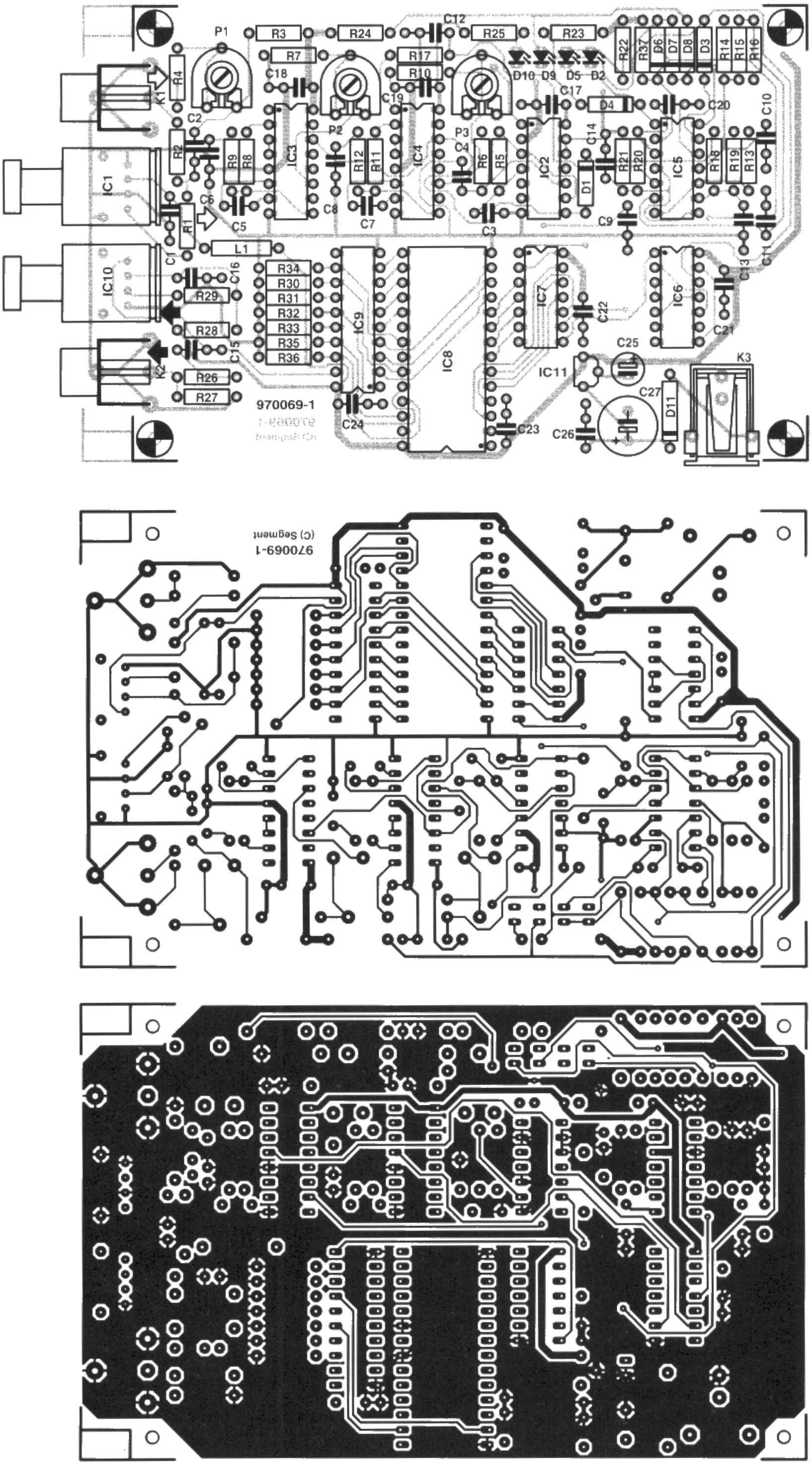
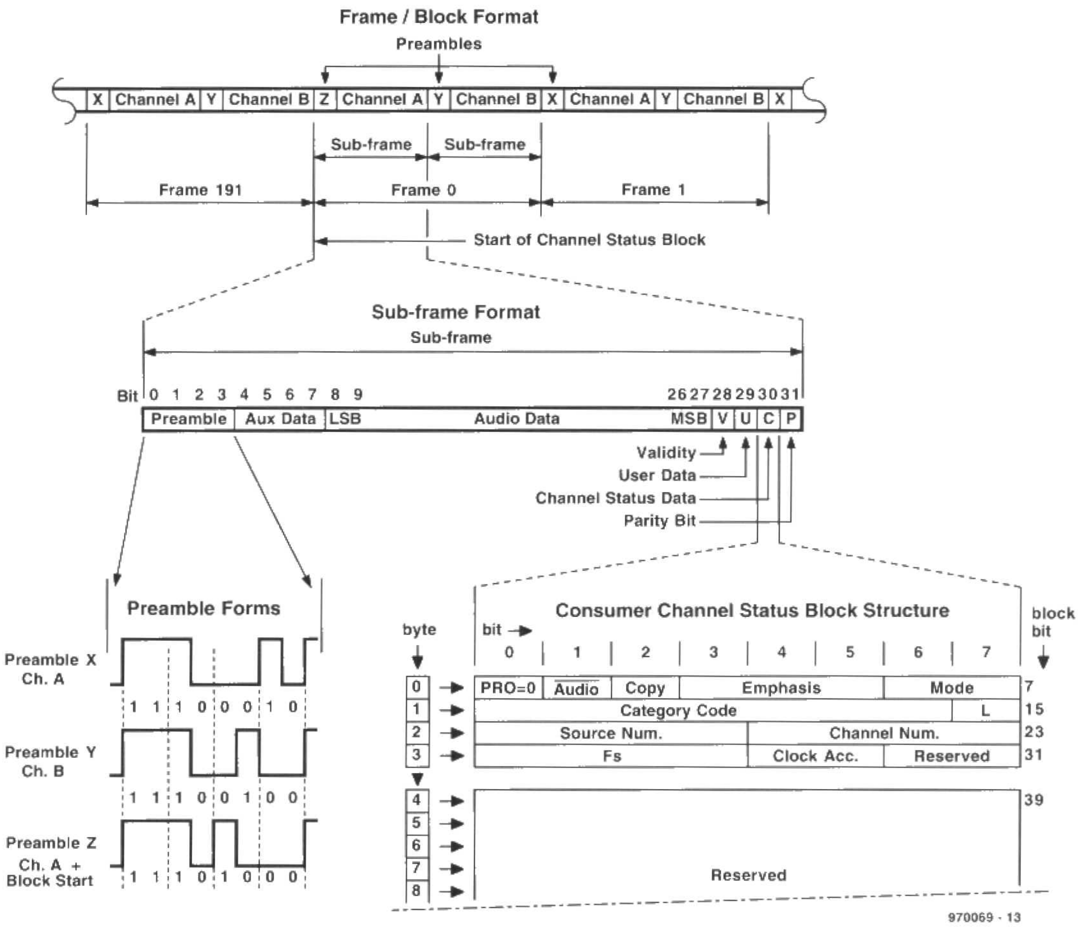


Figure 3. The printed-circuit board for the copybit killer is available ready-made.



Bit management

The digital part of the circuit, in conjunction with the associated programming code in the EPROM, provides a sequence control that recognizes and, if necessary, alters the status of the copy-prohibit-bit. The process attenuation of the S/PDIF signal is equal to one clock cycle. Shift register IC_7 continuously separates the last eight biphase-bit halves from the serial data stream and arranges that the halves are available at A_0–A_7.

The feedback of the data lines to the address lines via latch IC_9 divides the memory of the EPROM into 128 blocks of 256 bytes each. In this way it becomes possible within a block, depending on the status of address lines A_0–A_7, to select the same or another block which is then enabled at the rising edge of the next clock pulse. This arrangement provides processing control in up to 128 steps.

*From the format of the S/PDIF signal in the diagram above, it is seen that a transfer block consists of 192 frames, each of which is composed of two sub-frames. These sub-frames start with a preamble (**X**, **Y**, **Z**) and contain 32 bits. The preambles serve to mark the onset of a sub-frame; preamble **Z** also indicates the start of a new transfer block.*

Bit 2 of the Consumer Channel Status Block is of special importance for the present copybit killer, because unlimited digital copying can be carried out only when this bit is set. The Channel Status Bit is located at bit position 30 (biphase-bit-half positions 60 and 61) of a sub-frame and therefore occurs twice during each frame.

As far as the copy-prohibit-bit is concerned, these are the sub-frames of frame number 2.

In short, it is necessary that the status of bit number 30 in the two sub-frames of frame 2 be recognized and, if this bit has been erased, that it is set. If one of these bits is altered, the next parity bit (bit position 31) of the sub-frame must be inverted. This may give rise to eight different situations, which have to be taken into account in the programming code in the EPROM—see Table.

	User Data		Channel Status Data		Parity Bit	
Bit	29		30		31	
Bi-Bit	58	59	60	61	62	63
Case 1 C=0, P=1	* ↓ *	* ↓ *	0 ↓ 0	0 ↓ 1	1 ↓ 0	0 ↓ 0
Case 2 C=0, P=0	* ↓ *	* ↓ *	0 ↓ 0	0 ↓ 1	1 ↓ 0	1 ↓ 1
Case 3 C=1, P=0	* ↓ *	* ↓ *	0 ↓ 0	1 ↓ 1	0 ↓ 0	0 ↓ 0
Case 4 C=1, P=1	* ↓ *	* ↓ *	0 ↓ 0	1 ↓ 1	0 ↓ 0	1 ↓ 1
Case 5 C=1, P=1	* ↓ *	* ↓ *	1 ↓ 1	0 ↓ 0	1 ↓ 1	0 ↓ 0
Case 6 C=1, P=0	* ↓ *	* ↓ *	1 ↓ 1	0 ↓ 0	1 ↓ 1	1 ↓ 1
Case 7 C=0, P=0	* ↓ *	* ↓ *	1 ↓ 1	1 ↓ 0	0 ↓ 1	0 ↓ 0
Case 8 C=0, P=1	* ↓ *	* ↓ *	1 ↓ 1	1 ↓ 0	0 ↓ 1	1 ↓ 0

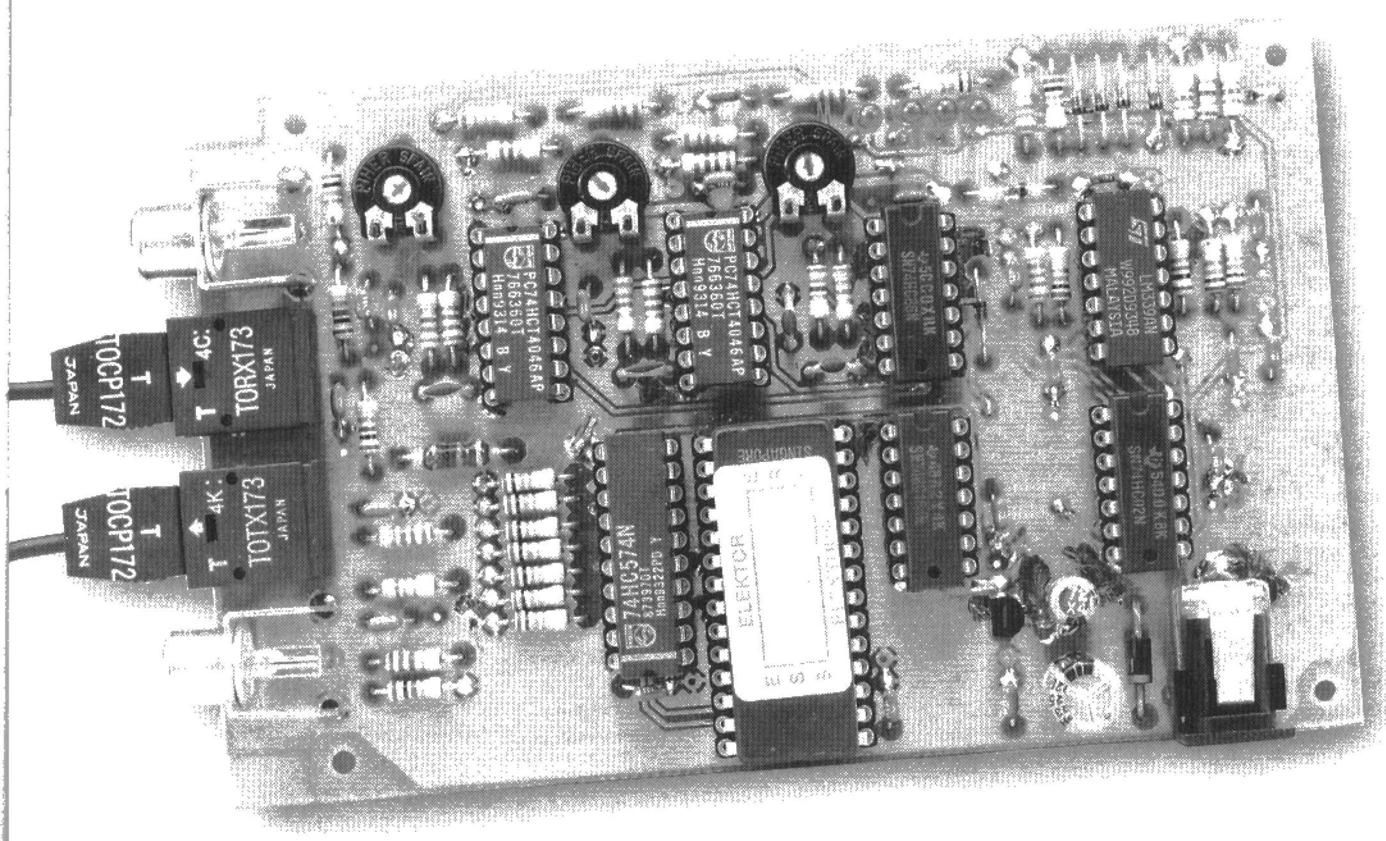


Figure 4. Illustration of the completed prototype board.

voltage at the relevant PLL (IC_3) is measured by comparators IC_{5b} and IC_{5d}. At the same time, the appropriate sampling frequency is indicated by D_2 or D_5.

The core of the copybit killer is the circuit for **decoding and disabling the copy-prohibit-bit**. This digital circuit consists of edge-triggered 8-bit shift register IC_7, 32 kbyte EPROM IC_8, and edge-triggered 8-bit latch IC_9.

Address lines A_0–A_7 of the EPROM are controlled via the shift register, while latch IC_9 provides the feedback of databits D_1–D_7 to addresses A_8–A_{14}. This arrangement, in conjunction with the software in the EPROM, ensures that the copy-prohibit-bit is recognized and disabled. The modified S/PDIF signal is available at pin 19 of the latch.

It would have been possible to use a programmed controller for this part ofthe copybit killer, but the cicuit as is forms a less expensive, readily available alternative to an EPLD. Moreover, programming an EPROM with conventional means is straightforward, which is an advantage that must not be underestimated.

The data for the EPROM is provided by a small Pascal program that produces a binary file of 32768 bytes. Constructors need not concern themselves with this since the programmed EPROM is readily available through our Readers' Services.

The **electrical-to-optical conversion** of the (modified) S/PDIF signal is effected by IC_{10}, an integrated transmitter from the same stable as the integrated input receiver.

The TTL output signal from latch IC_9 is converted by IC_{10} into an equivalent optical signal that can be passed on via a standard fibre-glass cable. Just as at the input, IC_{10} is shunted by a coaxial audio connector, K_2.

CONSTRUCTION

The copybit killer is best built on the printed-circuit board in **Figure 3**. Populating the board is straightforward by consulting the circuit diagram and parts list as well as the board itself.

All components are standard items. As mentioned earlier, IC_8 is available ready-programmed through our Readers' Services.

The functions of the four LEDs are:

- D_2 sampling frequency is 48 kHz;
- D_5 sampling frequency is 44.1 kHz;
- D_9 sampling frequency is 32 kHz;
- D_{10} input signal is absent or poor.

When the board has been completed, compare it with the photograph of the prototype in **Figure 4**.

The copybit killer may be powered by a mains adaptor via K_3. The adaptor output must not exceed 9–10 V to avoid the dissipation limit of IC_{11} being exceeded. Since the output of some adaptors is already 9 V when it is set to 6 V, it is advisable to actually measure the output.

The circuit draws a current of about 80 mA.

SETTING UP

Th trigger level at the input of the copybit killer is set with P_1. This is best done with the aid of an oscilloscope by making the pulses at the output (pin 8) of differentiating network IC_8 coincide with one another. This setting, which gives the least jitter., may be checked with other signal sources and sampling frequencies so as to obtain a good average.

Setting the VCO (IC_3) with P_2 is a precise operation. It has to be ensured that the voltage variation of about 220 mV at the output (pin 10) of IC_3 is symmetrical with respect to the input voltage to IC_{5b} and IC_{5d} (a window of about 80 mV) when the sampling frequency is switched from 44.1 kHz to 48 kHz and vice versa. This measurement is best carried out with a digital voltmeter.

The setting of the second VCO with P_3 is not so critical. Make sure, however, that the lighting of the relevant LED accords with the sampling frequency in use.

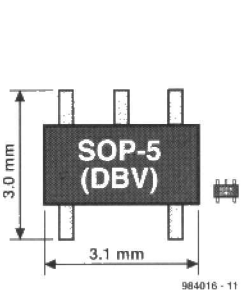
[970069]

006 microgate logic

Design: K. Walraven

This magazine regularly publishes news about new families of logic circuits. Last year, for instance, attention was drawn to the AHC (advanced high-speed CMOS) series. Logic circuits in this series are three times as fast as similar circuits in the HC (high-speed CMOS) series. An important benefit of the series is that devices can work from 3.3 V and 5 V supplies.

Later last year, Texas Instruments and Philips Semiconductors brought out a number of new, single-gate logic, devices in the AHC series. As the name indicates, these devices provide



only one gate and not four or six as had become usual. Single-gate logic circuits are housed in SOP-5 5-pin cases, which measure only 3×3.1 mm (quad-gate circuits housed in TSSOP 14-pin cases occupy 33.66 mm²).

The new devices are marketed under the name Microgate Logic. Although they are not revolutionary, they offer several real advantages. Designers no longer need to worry about gates not being used. Also, it becomes possible to locate the gate at a more suitable space on a board than quad gates. All this makes the devices more functional and more compact, which improves their EMC properties. The placing of quad-gate or six-gate devices on a board is almost invariably a compromise which makes signal lines unnecessarily long.

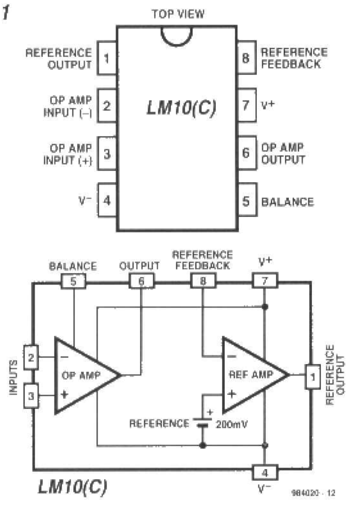
Microgate Logic devices are distinguished from normal AGC chips by the addition of 1G to the type number. For instance, a Type AHC1G00 is a single-gate logic 74AHC00, that is, a single NAND gate.

The AHC series is further extended by much larger devices to meet the requirements of 16-bit or 32-bit wide buses. These chips have more gates than before, and are marketed as Widebus™ circuits. For instance, a Type 74AHC16244 is a dual 244, that is, a 16-bit data buffer.

More information on these new circuits may be found on Internet page www.ti.com/-sc/docs/as1/lit.htm. [984016]

007 universal lead-acid battery protector

1



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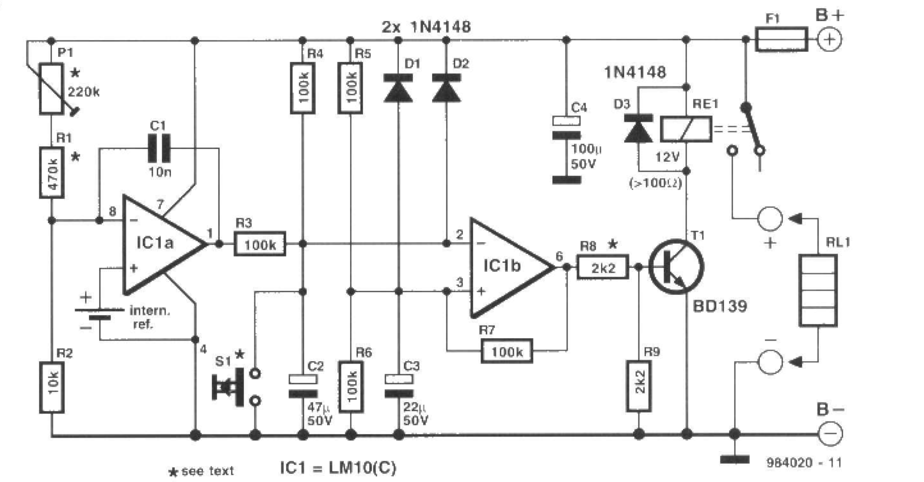


Design: L. Lalic

Lead-acid batteries must not be discharged deeply. In the best case, this leads to an irreversible loss of capacity; in the worst case, the likelihood of serious, irreparable damage is great. It is, therefore, rather odd that there are several circuits aimed at protecting these batteries to being overcharged, but hardly any to protect them against being discharged too deeply.

This situation is put right by the protector described here. It is intended to be placed between the battery and its load. It decouples the load from the battery when this is nearing the discharged state.

The circuit draws a current not exceeding 1 mA and is readily adapted for use with 6 V, 12 V, or 24 V lead-acid batteries. It may be equipped with an automatic or a manual reset function to override the decoupling of the load from the battery.

The circuit is based on a Type LM10C that contains an op amp and a reference amplifier. The pin out and circuit diagram are shown in **Figure 1**.

The IC has an integral voltage reference source of 200 mV which is internally linked to the non-inverting (+ve) input of a reference amplifier.

The integral op amp has an output stage that can be driven almost up to the level of the supply voltage. This means that it can provide a current of ±20 mA at a saturation voltage of only 400 mV.

The supply voltage range of the IC is 1.1–40 V and the device draws a current of only 270 µA. Note that the Type LM10CL cannot be used in this application since it is suitable for supply voltages of up to 7 V only.

In the circuit diagram in **Figure 2**, A_1 is the reference amplifier, which functions as monitor of the battery voltage. The battery voltage is lowered by voltage divider R_1-R_2-P_1 to the level of the reference potential of 200 mV. As long as the

battery voltage remains above the cell level of 1.83–1.85 V, the output of A_1 (pin 1) is low. This is of no consequence, since the inverting (–ve) input of op amp A_2 is held at half the supply voltage by R_4.

Op amp A_2 is arranged as a Schmitt trigger with switching levels at 1/3 and 2/3 of the supply voltage level via R_5, R_6 and R_7. The output of the op amp, pin 6, should go high immediately the supply is switched on and remain so as long as the battery is not discharged. This is arranged by C_2, C_3, D_1 and D_2.

Since the value of C_3 is only half that of C_2, the potential at pin 2 rises more slowly than that at pin 3. The output of A_2 thus goes high and remains so.

Diodes D_1 and D_2 ensure that C_2 and C_3 are discharged rapidly after the supply is switched off. This enables the circuit to be reactuated again quickly when necessary.

The high level at the output of A_2 causes T_1 to conduct, so that the relay is energized. The impedance of the relay coil should not exceed 100 Ω.

When the battery voltage drops below the critical level, the output of A_1 changes from low to high, whereupon the level at the inverting input of A_2 (pin 2) rises above the level of 2/3 the supply voltage. The output of A_2 goes low, T_1 is cut off, and the relay is deenergized, whereupon the load is decoupled from the battery.

Resistor R_4 limits any voltage variations at pin 2 of A_2 to the upper half of the supply voltage. This means that when the output of the op amp goes low, it stays so until a reset. This arrangement ensures that when the battery voltage recovers after the load has been decoupled, the protector is not reset automatically. Such a reset would almost always be undesired, since as soon as the load would be reconnected, it would be uncoupled again. The result would be an oscillatory process.

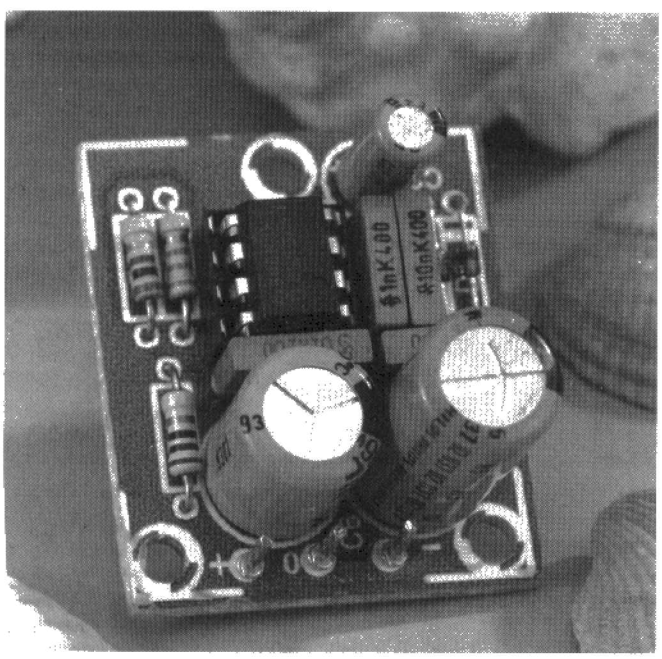
It is clear that a manual reset is better and this is effected by short-circuiting C_2 briefly by operating push-button switch S_1. Note that a reset also occurs when the supply is switched off and then on again. If, nevertheless, an automatic reset is desired, this is easily arranged by the removal of R_4. Be warned, however, that this makes sense only if the charging of the battery is started when the auto reset occurs.

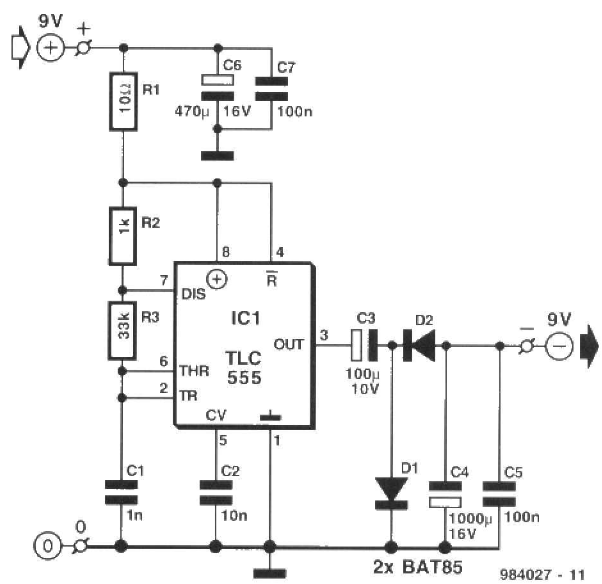
Calibrating the circuit is straightforward. Connect a variable power supply in place of the battery with a multimeter set to the 20 V direct voltage range parallel across its terminals. Adjust P_1 until the relay opens at a voltage of 5.5 V (6 V battery); 11 V (12 V battery) or 22 V (24 V battery).

The component values in the circuit diagram are for a 12 V battery version. In case of a 6 V battery, the value of R_1 must be lowered to 220 kΩ, that of R_8 to 1.2 kΩ, and that of P_1 to 100 kΩ. For a 24 V battery, the value of R_1 must be increased to 1 MΩ and that of R_8 to 4.7 kΩ.

Finally, the voltage rating of the relay coil must, of course, be the same as the nominal battery voltage. [R. Lalic – 984020]

008 dc-dc converter





This design is based on the celebrated 555 timer IC, and changes a positive voltage of 9 V into a negative one. A low-power dc-dc converter like the one shown here may be required sometimes when working with battery-powered equipment or older ICs that somehow call for a low-current negative bias. The circuit is also fine if you want to use a single battery to power a circuit requiring a symmetrical supply rails.

The TLC555 is a CMOS version of the older bipolar NE555. If you can not get hold of a TLC555, you may use the 7555 instead. Here, the TLC555 is connected up as an astable multivibrator with R2, R3 and C1 acting as the frequency determining components. The oscillation frequency is about 20 kHz. The squarewave produced by the oscillator has duty factor of about 0.5 and is fed to a cascade rectifier, C3-D1-D2-C4.

COMPONENTS LIST

Resistors:
R1 = 10Ω
R2 = 1kΩ
R3 = 33kΩ

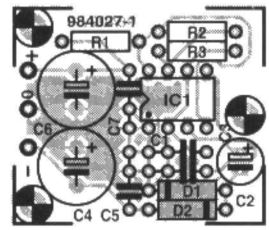
Capacitors:
C1 = 1nF
C2 = 10nF
C3 = 100µF 10V radial
C4 = 1000µF 16V radial
C5,C7 = 100nF
C6 = 470µF 16V radial

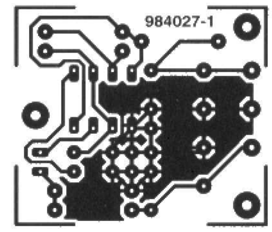
Semiconductors:
D1,D2 = BAT85
IC1 = TLC555 or 7555

Note that type BAT85 Schottky diodes are used because of their lower forward voltage drop of about 0.4 V as against 0.7 V for silicon diodes like the ubiquitous 1N4148. The rectified voltage is smoothed by C4, while C5 serves to eliminate higher-frequency noise.

The input supply voltage to the TLC555 is decoupled by R1, C6 and C7. Current consumption of the converter will depend largely on the load connected to the −9 V output. As evidenced by the measurement data in the table, the output should be capable of supplying up to about 10 mA before the output voltage plummets.

Battery voltage: 9.1 V			
R_L	I_S	V−	Efficiency
inf.	4.8 mA	−8.89 V	0%
6.8 k	6.0 mA	−8.3 V	18%
1.5 k	9.55 mA	−7.2 V	40%
680	13.43 mA	−5.93 V	42%





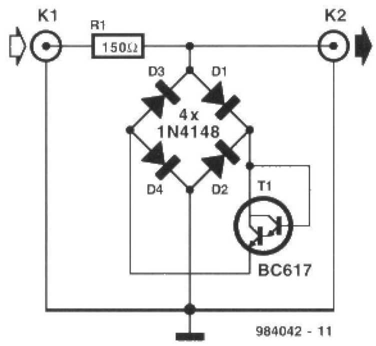
For easy incorporation in equipment in which space is at a premium, the converter is best built on the miniature circuit board whose artwork is shown here (board not available ready-made).

(984027-1)

009 overload protection

Design: T. Giesberts

Although the protection circuit is fairly simple, it forms an effective guard against overload of the input of amplifiers and loudspeakers. Why these inputs may need protection now that line levels have been standardized is because there are signal sources on the market that generate outputs of several volts instead of the standardized 1 V r.m.s. Also, in some applications, the loudspeaker signal is applied to the line output of a separate amplifier via a voltage divider, in which case the levels may be well above 1 V r.m.s.



The diagram shows a circuit that resembles the familiar series resistor and zener diode. Here, however, the zener is constructed from a small rectifier and a transistor, since commercial zeners appear to start conducting way below their rated values, which gives rise to unwanted distortion.

The constructed zener makes a well-defined limitation possible and does not affect signals below the critical level. Configuring T_1 as a diode reduces the number of components needed to a minimum: not even a voltage divider or potentiometer is required.

Measurements on the prototype show that the input signal remains virtually undistorted at levels up to 700 mV r.m.s. At the threshold of 1 V r.m.s., the distortion is about 0.02%. Above this level, limiting is well-defined. The peak output voltage of the circuit is about 3 V with an input voltage of about 13 V r.m.s. If the limiting level is required to be slightly higher, consideration should be given to replacing T_1 by three or four cascaded diodes. [984042]

010 rear light afterglow

(For bicycles with a dynamo)
Design: H. Bonekamp

This article is of interest only to readers whose bicycle lights are powered by a dynamo. The laws on bicycle lights in the United Kingdom are stricter than in other countries and a dynamo is, therefore, a rarity in this country.

From the point of view of traffic safety it is advisable (in UK obligatory) for cyclists to have the rear lamp of their bicycle to light even when they are at standstill. In principle, it is not very difficult to modify the existing rear light with afterglow: all this needs is a large enough energy reservoir. Since the afterglow is required for short periods of time only, a battery is not required: a large value capacitor, say, 1 F, is quite sufficient.

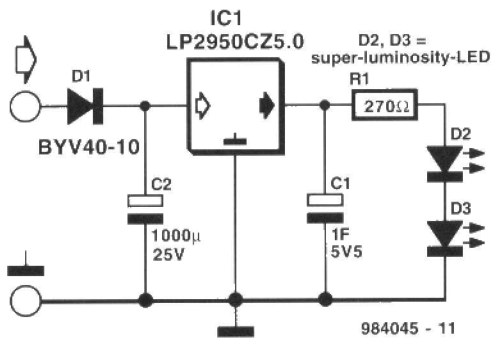
As the diagram shows, in the present circuit, the normal rear light bulb is replaced by two series-connected bright LEDs, D_2 and D_3. These are clearly visible with a current of only 6 mA (compared with 50 mA of the bulb). The current is set with series resistor R_1.

The LEDs are shunted by the 1 F capacitor, C_1. Since the working voltage of this component is only 5.5 V, it is, in spite of its high value, physically small.

An effective regulator is needed to limit the dynamo voltage adequately. Normal regula-

tors cannot be used here, since they do not work at low voltages. Moreover, such a device would discharge the capacitor when the cycle is at standstill. Fortunately, there is a low-drop type that meets the present requirements nicely: the Type LP2950CZ5.0.

Of course, the dynamo output voltage needs to be rectified before it can be applied to the regulator. In the present circuit, this is effected by half-wave rectifier D_1 and buffer capacitor C_2. Diode D_1 is a Schottky type to keep any losses low – important for this application, because the ground connection via the bicycle frame usually causes some losses as well.



The value of buffer capacitor has been chosen well above requirements to ensure that C_1 is charged during the negative half cycles of the dynamo voltage.

[984045]

011 "chip card" as security key

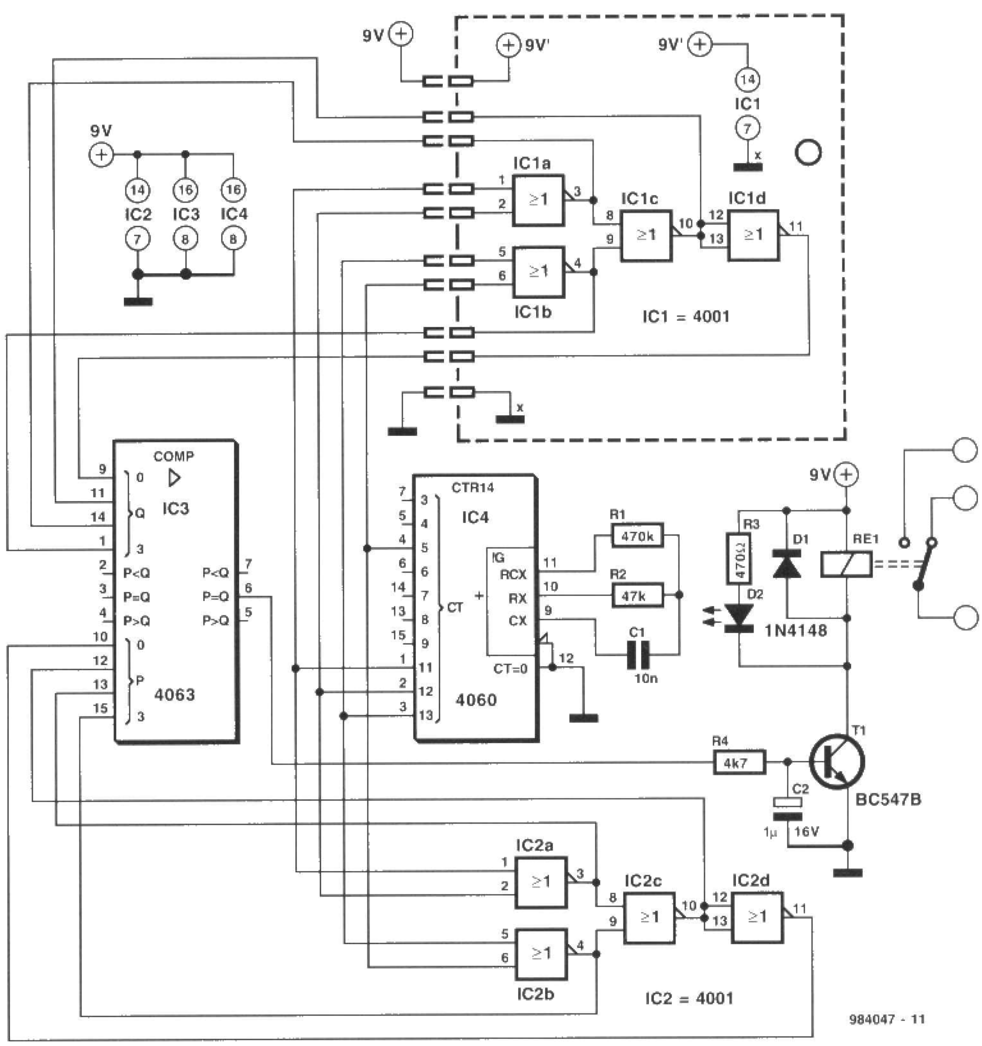
Design: P. Lay

The "chip card" consists of a small board on which an integrated circuit, IC_1, forms the key. The logic circuit for the key is hard-wired. The inputs and outputs of this circuit are terminated in a socket, St_1. It is, of course, advisable to use a surface-mount device (SMD) for IC_1 (as well as for the other ICs in the circuit) and a microminiature or miniature type of socket (and matching plug, Bu_1), to keep the safety key as small as possible.

An identical circuit, based on IC_2, must be built for the lock into which the key fits. Added to this are 4-bit comparator IC_3, and 14-stage binary counter IC_4.

The comparator likens the logic circuit in the lock with that in the key. To that end, both circuits are fed with a 4-bit signal by the binary counter. If the two match, the output of IC_3 goes high and switches on transistor T_1, whereupon the relay is energized and diode D_2 lights. Any short, l9w-level pulses caused by the difference in transit times are suppressed by capacitor C_2.

It is, of course, essential that the hard-wiring in the key and lock are identical. It is advisable to protect the wiring in the key from prying eyes by removing the typecoding from IC_1 before it is wired in, and additionally to use opaque casting resin for embedding the key.



In the circuit as shown, there is a remote possibility that, owing to a spurious voltage across R_4-C_2, the relay is energized even though the comparison between the key and lock is not 100 per cent right. This may be obviated by shunting R_4 with a Type 1N4148 diode (anode to base of T_1).

The circuits need a supply voltage of 5–15 V, but care should be taken to ensure that the rated voltage for the relay is available. In the quiescent state, the circuits draw a current of about 1 mA, and in the operating state a current wholly determined by the relay.

[984047]

developments in battery chargers

for NiCd, NiMH & Li+ batteries

Electronic equipment is increasingly becoming smaller, lighter, and more functional, thanks to the push of technological advancements and the pull from customer demand. The result of these demands has been rapid advances in battery technology and in the associated circuitry for battery charging and protection.

For many years, nickel-cadmium (NiCd) batteries have been the standard for small electronic systems. A few larger system, such as laptop computers and high-power radios, operated on sealed lead-acid batteries. Eventually, the combined effects of environmental problems and increased demand on the batteries led to the development of new battery technologies: nickel-metal hydride (NiMH), rechargeable alkaline, and lithium-ion (Li+). These new battery technologies require more sophisticated charging and protection circuitry.

NICD AND NIMH BATTERIES

NiCd has long been the preferred technology for rechargeable batteries in portable electronic equipment, and in some ways NiCd batteries still outperform the newer technologies. NiCd batteries have a smaller capacity than Li+ or NiMH types, but their low impedance is attractive in applications that require high current for short periods. Power tools, for example, will probably continue to use NiCd packs indefinitely.

A Maxim Report

1

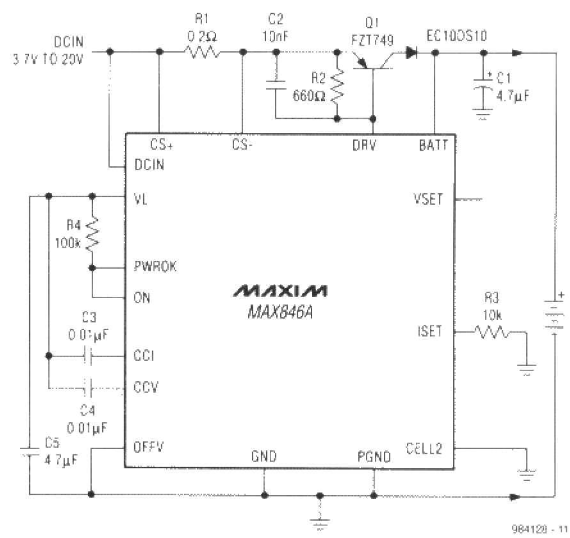


Figure 1. Designed for single lithium-ion cells, this battery-charging circuit is ideal for use in a stand-alone cradle charger.

Though similar to NiCd types, NiMH batteries have greater capacity. This advantage is offset somewhat by the NiMH battery's higher self-discharge rate—approximately double that of the NiCd battery, which is relatively high to begin with (about 1% of capacity per day). So, NiMH batteries are not suitable for applications in which the battery is expected to hold its charge for a long time.

NiMH batteries also differ from NiCd batteries in the method required to fast-charge them. Both types can be fast-charged with a current equal to or greater than the capacity (C) in ampere-hours. This technique allows you to charge a battery in about an hour or less. Because of internal losses, a battery charged at C for one hour cannot reach full capacity. For full capacity, you must either charge for an hour at more than C, or charge at C for more than an hour. Charging losses vary with the charging rate and from battery to battery.

When a NiCd battery is being charged, its terminal voltage peaks and then declines as the battery reaches capacity. An applied fast charge should therefore terminate when this voltage starts to drop (that is, when $\Delta U/\Delta t$ becomes negative). Otherwise, the charging current delivers excess energy, which acts on the battery' electrolyte to dissociate water into hydrogen and oxygen. This results in a rise in internal pressure and temperature and a decrease in terminal voltage. If fast charging continues, the battery can vent (explode).

As a secondary or backup measure, NiCd and NiMH battery chargers often monitor the battery's temperature (in addition to its voltage) to ensure that fast charging is terminated before the battery is damaged. Fast charging should stop when a NiCd's $\Delta U/\Delta t$ becomes negative. For NiMH batteries,

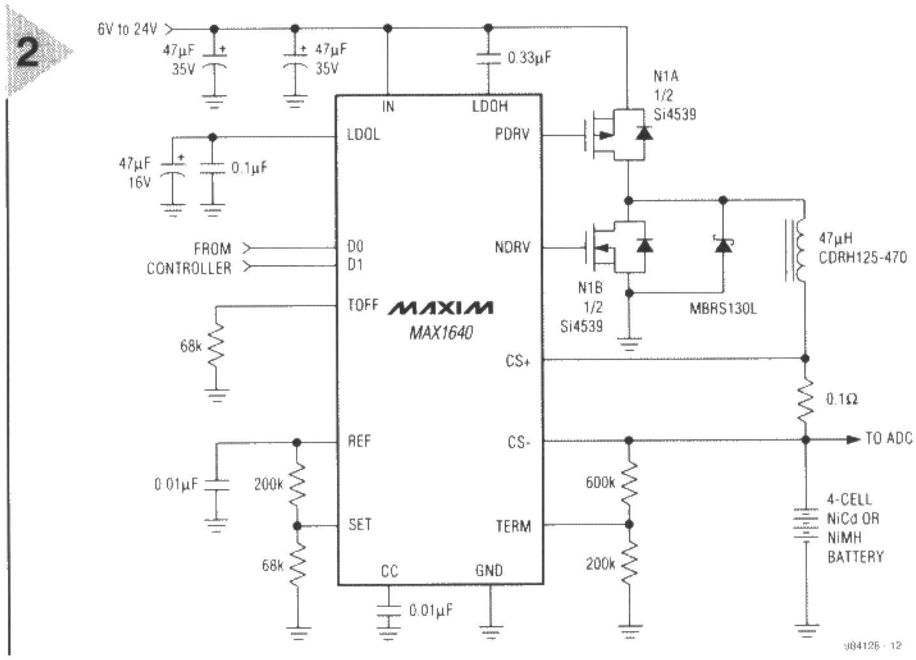


Figure 2. This four-cell NiCd or NiMH battery charger can be incorporated into a larger system.

fast charging should stop when the terminal voltage peaks, that is when $\Delta U/\Delta t$ goes to zero.

Trickle-charging is simple for NiCd and NiMH batteries. As an alternative to fast charging, the use of a small trickle current produces a relatively small rise in temperature that poses no threat of damage to the battery. There is no need to terminate the trickle-charge or to monitor the battery voltage. The maximum trickle current allowed varies with battery type and ambient temperature, but C/15 is generally safe for typical conditions.

LITHIUM-ION BATTERIES

The most popular innovation in battery technology over the past few years has been the introduction of Li+ batteries. These batteries have a higher capacity than other rechargeable types now in mass production, such as NiCd and NiMH. The advantage of Li+ over NiMH is only 10–30% when measuring capacity as energy per unit volume, but volumetric capacity is not the only property to consider: weight is also important in portable devices. When the capacity is measured as energy per unit mass, Li+ batteries are clearly superior (NiMH batteries are relatively heavy). Because they are lighter, Li+ batteries have nearly twice as much capacity per unit mass.

Li+ batteries also have many limitations. They are highly sensitive to overcharging and undercharging. You must charge to the maximum voltage to store maximum energy, but excessive voltage can cause permanent damage to a Li+ battery, as can an excessive charging or discharge current. Discharging the battery also carries a caveat: repeated discharges to a sufficiently low voltage can cause a loss of capacity. Therefore, to protect the battery, you must limit its current and voltage when it is being discharged as well as when it is being charged. Most Li+ battery packs include some form of undervoltage- and overvoltage-disconnect circuitry. Other typical features include a fuse to prevent exposure to excessive current and a switch that opens-circuits the battery if high pressure causes it to vent.

Unlike NiCd and NiMH batteries, which require a current source for charging, Li+ batteries must be charged with a combination current-and-voltage source. To achieve the maximum charge without damage, most Li+ battery chargers maintain a 1% tolerance on the output voltage. (The slight additional capacity gained with a tighter tolerance is generally not worth the extra difficulty and expense required to achieve it.)

For protection, a Li+ battery pack usually includes MOSFETs that open-circuit the battery in the presence of undervoltage or overvoltage. These protections MOSFETs also enable an alternative charging method (applying a constant current with no voltage limit) in which the MOSFETs are turned on and off as necessary to maintain appropriate battery voltage. The battery's capacitance helps to slow the rise of battery voltage, but use caution: battery capacitance varies widely over frequency, as well as from battery to battery.

In some applications, intermittent loads can exceed the main battery's power capability. A solution to this problem is to provide an additional, rechargeable battery to supply the excess current during a high-load transient. The main battery then recharges the auxiliary battery in preparation for the next transient. Two-way pagers are a good example of this arrangement. Pagers generally run from a single AA alkaline battery, but the load during transmission is to high for an AA battery to handle. An additional NiCd battery powers the transmitter, and it can be recharged when the transmitter is off, which is most of the time.

CRADLE CHARGERS

For cell phones and many other small devices, the preferred battery-charging method involves the use of a separate cradle charger into which you place the device or the battery pack. Because the charger unit is separate, its generated heat of less concern than it would be if the charger were integrated into the device.

The simplest circuit for use in a cradle charger is usually a linear-regulator charger. Linear regulators drop the difference voltage (between the direct voltage power source and the battery) across a pass transistor operating in its linear region (hen ce the name linear regulator). However, the dissipated power (the charging current times the drop across this transistor) can cause overheating if the charger is confined to a small space without airflow.

For example, consider a four-cell NiCd battery being charged at 1 A. NiCd batteries usually terminate charging at approximately 1.6 –1.7 V per cell, but the voltage can be as high as 2 V per cell, depending on the battery's condition and its charging rate. The d.c. source voltage must therefore be greater than 4 × 2 V = 8 V. The voltage level of cells in a fully discharged battery can measure as low as 0.9 V each; in this case, the battery voltage is 4 × 0.9 V = 3.6 V. If the d.c. source voltage is 8 V, the pass transistor sees 8–3.6 = 4.4 V.

When a fully discharged battery is being charged, the dissipated power is 4.4 W in the charger and 3.6 W in the battery—an efficiency of only 45%! The actual efficiency is even lower, because the source voltage must be higher than 8 V to account for dropout voltage in the pass transistor and tolerance in the source.

A linear, single-cell Li+ battery charger is suitable for use in a cradle charger (Figure 1). It drives an external power transistor, Q_1, that drops the source voltage down to the battery voltage. The external transistor accounts for most of the circuit's power dissipation; the controller temperature therefore remains relatively constant. The result is a more stable internal reference, yielding a more stable battery-voltage limit.

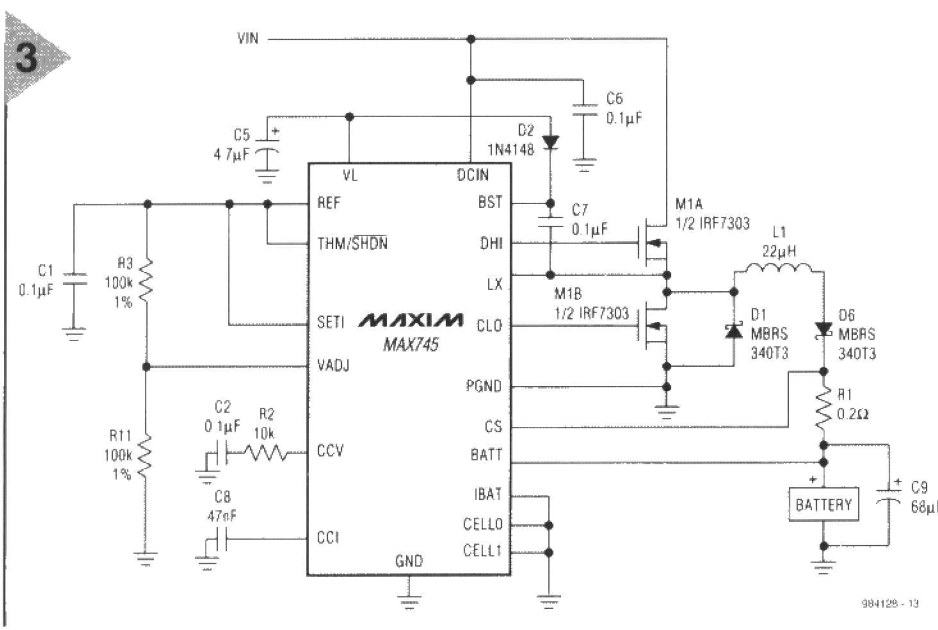


Figure 3. This charger generates a 1%-accurate charging voltage suitable for charging two lithium-ion batteries in series.

Resistors R_1 and R_3 determine the output current: R_1 senses the charging current and R_3 sets the level at which the current is regulated. The current out of the ISET terminal is equal to 1/1000 of the voltage between CS+ and CS–. The current regulator controls the ISET voltage at 2 V; in this case, the current limit, $2000/(R_1 + R_3)$, is 1 A.

Control loops for the voltage and current limits have separate compensation points (VVC and CCI), which simplifies the task of stabilizing these limits. The ISET and VSET terminals allow for adjustment of the current and voltage limits.

BUILT-IN BATTERY CHARGERS

In some larger systems, including laptop computers, the battery charger is built in as part of the system. The charger's efficiency in this arrangement is critical—not to ensure maximum energy transfer, but simply to minimize heat generation. Heat elevates temperature, and operation at elevated temperatures shortens a battery's life. Because this application requires high efficiency over the entire battery-voltage range, the charger should rely on a switching regulator, whose power dissipation is relatively low and independent of the input-to-output voltage drop.

The main drawback of switching regulators is the need for a passive *LC* filter, which converts the switched output voltage to a direct voltage whose level is suitable for the battery. In some case, the battery capacitance is sufficient to replace the capacitor in the filter; however, as mentioned earlier, a battery's capacitance can vary greatly with frequency. Determine it carefully before committing to a design.

Another drawback of switching regulators is the noise generated by their switching action. This problem can usually be avoided with proper layout techniques and shielding. For applications in which certain frequencies should be avoided, many switching chargers can be synchronized to an external signal—a capability that allows you to shift the charger's switching noise away from sensitive frequency bands.

A linear regulator is generally larger than an equivalent switching regulator because it dissipates more power and requires a larger heat sink. Consequently, the extra time necessary to design a smaller, more efficient switching charger is usually justified. One such design is the 4-cell NiCd/ NiMH charger in Figure 2. It has no provision for terminating the charging; it operates in conjunction with a controller that monitors the voltage across the battery and shuts off the charger when conditions are met. Many systems already include a controller suitable for this purpose. If your system does not have one, you will need a low-cost, stand-alone microcontroller (μC) that includes an on-board analogue-to-digital converter (ADC). A number of such μCs are available.

The charger IC chops the input voltage with a switching transistor, N1A and a synchronous rectifier, N1B. This chopped voltage is placed across the inductor to form a current source. When the charger is turned off, diode D_2 prevents current flow from the charged battery back into the voltage source.

In addition to 'off', the MAX1640 operates in one of three modes as determined by digital inputs D0 and D1: fast charge, pulse trickle charge, and top-off charge (Table 1). In the fast-charge mode, the charging current is 150 mV divided by the current-sense resistor value (0.1 Ω) or 1.5 A in this case. In top-off-charge mode, the voltage at SET produces 24.5% of the fast-charge current, or 381 mA in this case. The current in pulse-trickle-charge mode is the same as in top-off mode, but it is pulses with a 12.5% duty cycle. Frequency is determined by the resistor connected at TOFF (68 kΩ). In this case, the frequency is 3.125 MHz/R_3 = 46 Hz. The average pulse-trickle current is therefore $0.125 \times 381 =$ 4.76 mA.

The circuit in Figure 2 should terminate a charge when $\Delta U/\Delta t$ equals zero or becomes negative (according to whether a NiMH or a NiCd battery is being charged). However, if terminations fails to occur, the circuit imposes a secondary voltage limit to prevent the battery voltage from rising too high. As an absolute maximum, the charging voltage for NiCd and NiMH batteries should not exceed 2 V per cell, or 8 V for the 4-cell battery in this circuit. Resistors R_6 and R_7 establish this voltage limit as $U_{limit} = U_{ref}$ $[R_7/(R_6+R_7)]$.

A similar circuit charges two Li+ cells in series (Figure 3). It differs mainly in the accuracy of its charging voltage, which is better than the 1% required by Li+ batteries. Also unlike the charger in Figure 2, this one uses an n-channel MOSFET for the high-side switching transistor. When turned on, this transistor's source and drain voltages are approximately equal to V_{IN}, but the gate voltage must be higher than V_{IN} to allow the use of inexpensive n-channel MOSFETs. This elevated gate drive is achieved by charging C_7 and adding its voltage to V_{IN}.

Charging current for the circuit shown in Figure 3 is determined by current-sense resistor R_1: 185 mV/R_1 = 925 mA for the 200 mΩ value shown. This current can be adjusted linearly to lower values by varying the voltage at the SET1 terminal. Similarly, you can adjust V_{OUT} by varying the voltage at the V_{ADJ} terminal. Because varying V_{ADJ} over its full range (0–4.2 V) changes V_{OUT} by only 10% (0.4 V per cell), you can achieve better than 1% output accuracy with 1% resistors. (One-percent-accurate resistors degrade the output accuracy by only 0.1%).

Terminals CELL0 and CELL1 set the battery's cell count as shown in Table 2. (VL indicates the 5 V level that powers the IC.) The charger can handle as many as four Li+ cells in series. Though not shown in Figure 3, the MAX745 can also terminate charging upon reaching a temperature limit monitored by a thermistor. When the battery temperature exceeds this limit

(determined by an external resistor and thermistor connected to the THM/$\overline{SHDN}$ terminal), the charger shuts off. Hysteresis associated with this threshold enables the system to resume charging when a declining battery temperature causes the THM/SHDN voltage to fall 200 mV below its 2.3 V threshold.

SMART-BATTERY CHARGERS

Smart batteries represent a new technology that is helping designers and consumers alike. Smart-battery packs include a controller that can 'talk' through its serial port to tell an external charger what kind of charging routine the battery requires. This arrangement helps designers, because they can design a single charger that handles all batteries compliant with the smart-battery standard.

Smart batteries also benefit consumers, who can replace a given battery without regard to its type, as long as the replacement is smart-battery compliant. The smart-battery specification allows any manufacturer to participate in the market, and the resulting competition leads to standard products and lower prices.

The smart-battery specification was defined by a consortium of companies that manufacture batteries, computers, and related products. It defines the way the battery pack connects to the host system and the way it communicates with the host. It communicates via a two-wire serial interface known as the System Management Bus (SMBus™), which is derived from the I²C protocol. A large base of I₂C-compliant µCs capable of controlling peripherals on the SMBus is available.

Smart batteries also provide an elegant solution to the problem of fuel gauging. In a system run by ordinary non-communication batteries, the host knows the state of the battery only when it has been fully charged or discharged. Smart batteries, on the other hand, remember their charge state. When such batteries are switched in and out of the host, the fuel gauge is able to maintain the same level of accuracy as it would under continuous operation.

In the smart-battery compliant charger shown in Figure 4, the controller IC includes an SMBus interface that allows it to communicate with the host computer and the smart battery being charged. Because the switching regulator and its small, power-efficient current-sense resistor cannot achieve a 1 mA (min) resolution in charging current, the first 31 mA (five LSBs) of output current are supplied by an internal linear current source.

To preserve high efficiency (89%), the system actuates a switch-mode current source when programmed for output currents of 32 mA or higher. However, the linear source remains on to ensure monotonicity in the output current regardless of the current-sense resistor's value or offset in the current-sense amplifier. Transistor Q_1 off-loads an otherwise heavy power dissipation in the internal linear regulator, which occurs when the the input voltage is much greater than the battery voltage. The base of Q_1 is held about 5 V below the input voltage. The voltage across the internal current source does not exceed 5 V; therefore, the power dissipation in the current source remains below 160 mW.

A diode, D_3, is placed in series with the inductor to prevent a flow of reverse current out of the battery.

The high switching frequency (250 kHz) of IC_2 permits the use of a small inductor. The circuit accepts inputs as high as 28 V, and provides pin-selectable maximum output currents of 1 A, 2 A, and 4 A.

(984128)

SMBus is a trademark of Intel Corp.

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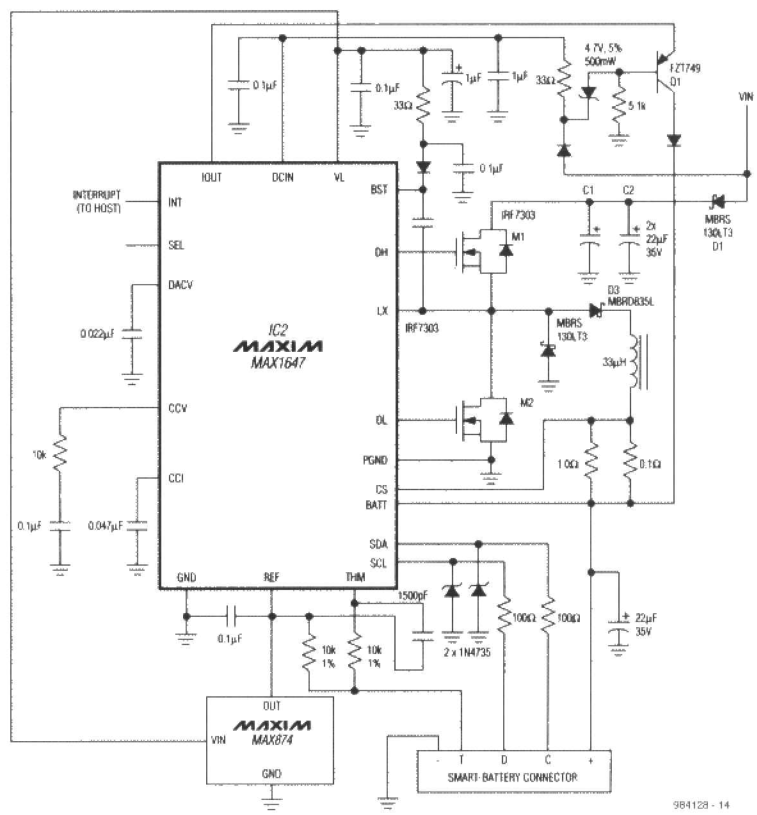


Figure 4. This charger is compliant with the smart-battery specification, and communicates with the host computer and a smart battery via the SMBus™ interface.

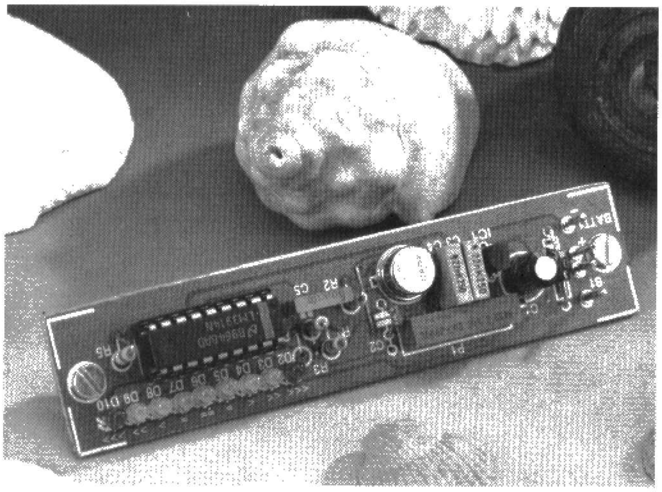
Table 1. Charging states for the MAX1640

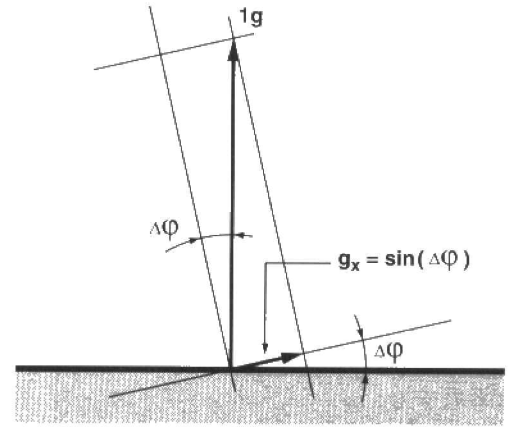
D_0	D_1	Mode	Output current
0	0	off	
0	1	top-off charge	$V_{SET}/13.3\ R_{SENSE}$
1	0	pulse-trickle charge	$V_{SET}/13.3R_{SENSE}$ (12.5% duty cycle)
1	1	fast charge	$V_{REF}/13.3R_{SENSE}$

Table 2. Cell-count setting for the MAX745

Cell 0	Cell 1	Number of cells
GND	GND	1
VL	GND	2
GND	VL	3
VL	VL	4

012 electronic spirit-level





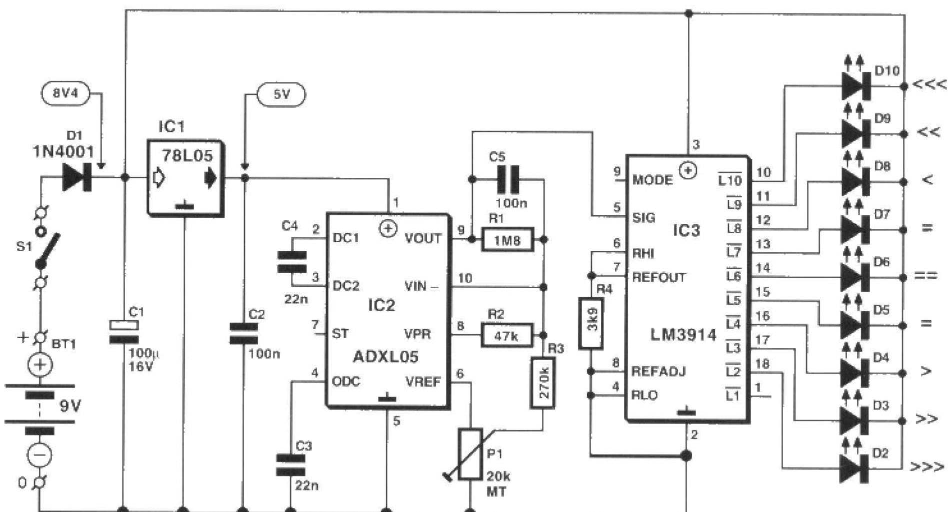
984038 - 11

Design: H. Bonekamp

This is an electronic equivalent of the traditional builder's spirit-level using a small glass tube nearly filled with alcohol but containing an air-bubble whose position allows you to test a surface for horizontality.

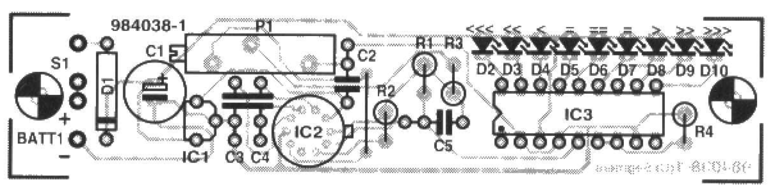
The heart of the circuit is an ADXL05 gravity force (g) sensor from Analog Devices [1,2]. This sensor will detect a relative gravitational force of 0 g when positioned horizontally. The sensor has a sensitivity of about 200 mV/g. Its internal output buffer is set to supply a gain equal to (R1/R2) or about 38.3 times, so that the standard sensitivity is increased to 7.66 V/g.

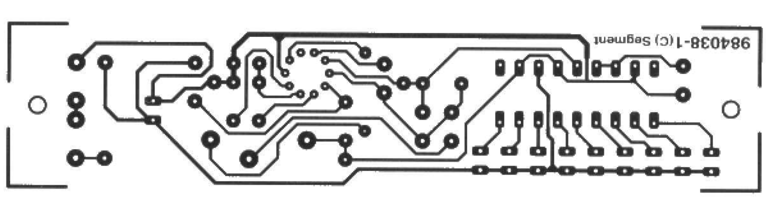
The output of the ADXL05, pin 9, drives the signal input of an LM3914 ADC annex LED-bar driver, IC3. The one resistor



984038 - 12

$H_{sensor} = 200\text{mV}/g$
$H_{amp} = R1/R2 = 1.8/0.047 = 38.3$
$H_{LM3914} = 8\ \text{LED/V}$
$H = H_{sensor} \times H_{amp} \times H_{LM3914} = 0.2 \times 38.3 \times 8 = 61.3\ \text{LED}/g$
$1/H = 16.3\text{m}g/\text{LED}$
$\Delta\varphi/\text{LED} = \arcsin(1/H) \sim 1\ \text{degree/LED}$





COMPONENTS LIST

Resistors:
R1 = 1MΩ8
R2 = 47kΩ
R3 = 270kΩ
R4 = 3kΩ9
P1 = 20kΩ multiturn preset, horizontal

Capacitors:
C1 = 100μF 16V radial
C2 = 100nF Sibatit (Siemens)
C3,C4 = 22nF MKT (Siemens)
C5 = 100nF MKT (Siemens)

Semiconductors:
D1 = 1N4001
D2,D10 = LED, red, high efficiency
D3,D4,D8,D9 = LED, yellow, high efficiency
D5,D6,D7 = LED, green, high efficiency
IC1 = 78L05
IC2 = ADXL05JH (Analog Devices)
IC3 = LM3914N

Miscellaneous:
S1 = on/off switch, 1 make contact.
9-V PP3 battery with clip-on connector and wires.
Printed circuit board, order code 984038-1.

connected to the LM3914, R4, determines that the full-scale LED, D10, lights at an input voltage of 1.25 V. Consequently, the LED bar has a step size of 0.125 V, while the sensitivity of the spirit-level works out at 16.32 *mg* per LED, or one LED for each degree of slant angle.

It should be noted that the operation of the circuit is affected by temperature variations. The drift being 0.4 mV per degree Celsius at unity gain, the rate of change (temperature drift gradient) at the output equals 15 mV/°C for a gain of 38.3 times. This, in turn, equals a gradient of 8 °C per LED, so the circuit has to be calibrated before use.

Preset P1 and resistor R3 double as a network for offset compensation (approx. ±0.3 V) as well as for ensuring that the centre LED, D6, lights when the sensor is held exactly horizontal (0-*g* potential). The preset, P1, is then adjusted until D6 lights. Assuming that the sensor is on a fairly horizontal surface, you then turn the instrument 180 degrees. The number of active LEDs which is then shifted to the left or to the right is divided by two, and P1 is carefully adjusted until this number is shifted around D6. Check by turning the circuit 180 degrees again — the error with respect to D6 should be equal but in the opposite direction. The all-solid state spirit-level draws a current of about 20 mA from a 9-volt PP3 battery. (984038-1)

References:

1. Accelerometer Type ADXL05 (Application Note), *Elektor Electronics* April 1997.
2. *Electronic Accelerometer*, *Elektor Electronics* June 1998.

013 low-drop 5 V regulator

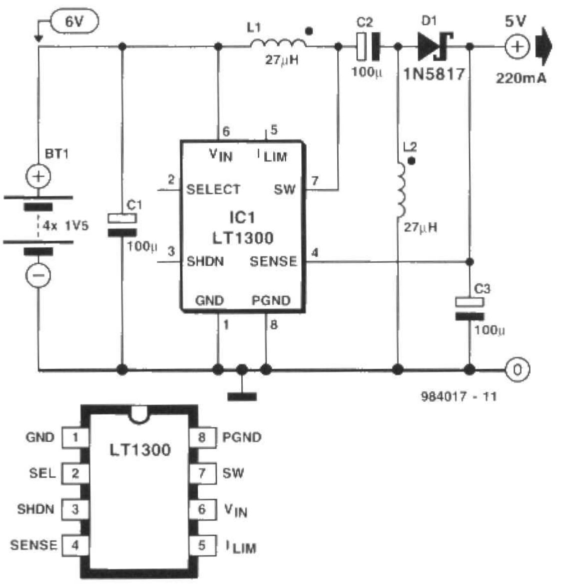
Linear Technology Application

A 4-cell pack is a convenient, popular battery size. Alkaline manganese batteries are sold in retail stores in packs of four, which usually provide sufficient energy to keep battery replacement frequency at a reasonable level.

Generating 5 V from four batteries is, however, a bit tricky. A fresh set of four batteries has a terminal voltage of 6.4 V, but at the end of their life, this voltage is down to 3.2 V. Therefore, the voltage needs to be stepped up or down, depending on the state of the batteries.

A flyback topology with a costly, custom designed transformer could be used, but the circuit in the diagram gets around the problem by using a flying capacitor together with a second inductor.

The circuit also isolates the input from the output, allowing the output to go to 0 V during shutdown.



The circuit can be divided conceptually into boost and buck sections. Inductor L_1 and switch IC_1 comprise the boost or step-up section, and inductor L_2, diode D_1 and capacitor C_3 form the buck or step-down section.

Capacitor C_2 is charged to the input voltage, V_{in}, and acts as a level shift between the two sections. The switch toggles between ground and $V_{in}+V_{out}$, while the junction of L_2, C_2 and D_1 toggles between $-V_{in}$ and $V_{out}+V_{d1}$.

Efficiency is directly related to the quality of the capacitors and inductors used. Better quality capacitors are more expensive. Better quality inductors need not cost more, but normally take up more space. The Sanyo capacitors used in the prototype (C_1–C_3) specify a maximum ESR (effective series resistance) of 0.045 Ω and a maximum ripple current rating of 2.1 A. The inductors used specify a maximum DCR (direct current resistance) of 0.058 Ω.

Worst-case r.m.s. current through capacitor C_2 occurs at minimum input voltage, that is, 400 mA at full load with an input voltage of 3 V. [984017]

014 liquid-crystal display (LCD) tester

Design: K. Walraven

Liquid-crystal displays come in all sorts and sizes, and this applies also to their pinouts. In fact, many of these displays cannot be used properly without the manufacturers' documentation. But, of course, this can never be found when it is needed, and a small tester to unravel the terminals may, therefore, be found very handy.

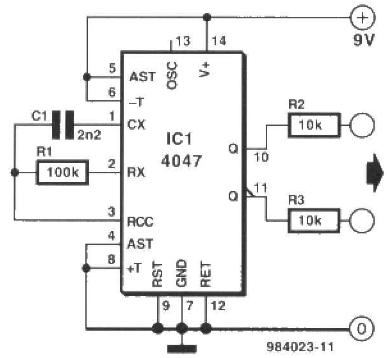
A liquid-crystal display consists of two thin sheets of glass, the facing surfaces of which have been given thin conducting tracks. When the glass is looked through at right or near-right angles, these tracks cannot be seen. At certain viewing angles, they become visible, however.

The space between the sheets of glass is filled with a liquid that, stimulated by an electric voltage, alters the polarization of the incident light. In this way, segments may appear light or dark and give rise to the display of lines or shapes.

A segment may be tested by applying an alternating voltage of a few volts across it. Note that the application of a direct volt-

age will damage the display irreversibly: the resulting current will remove the tracks. The alternating voltage should contain not even a tiny direct voltage component. An alternating current also removes part of the tracks when the current flows in one direction, but restores it when the current flows in the opposite direction.

The tester described here consists of a square-wave generator that produces an absolutely symmetrical alternating voltage without any d.c. component. Most logic oscillators are incapable of producing a square-wave signal: they generate rectangular waveforms whose duty cycle hovers around the 50%.

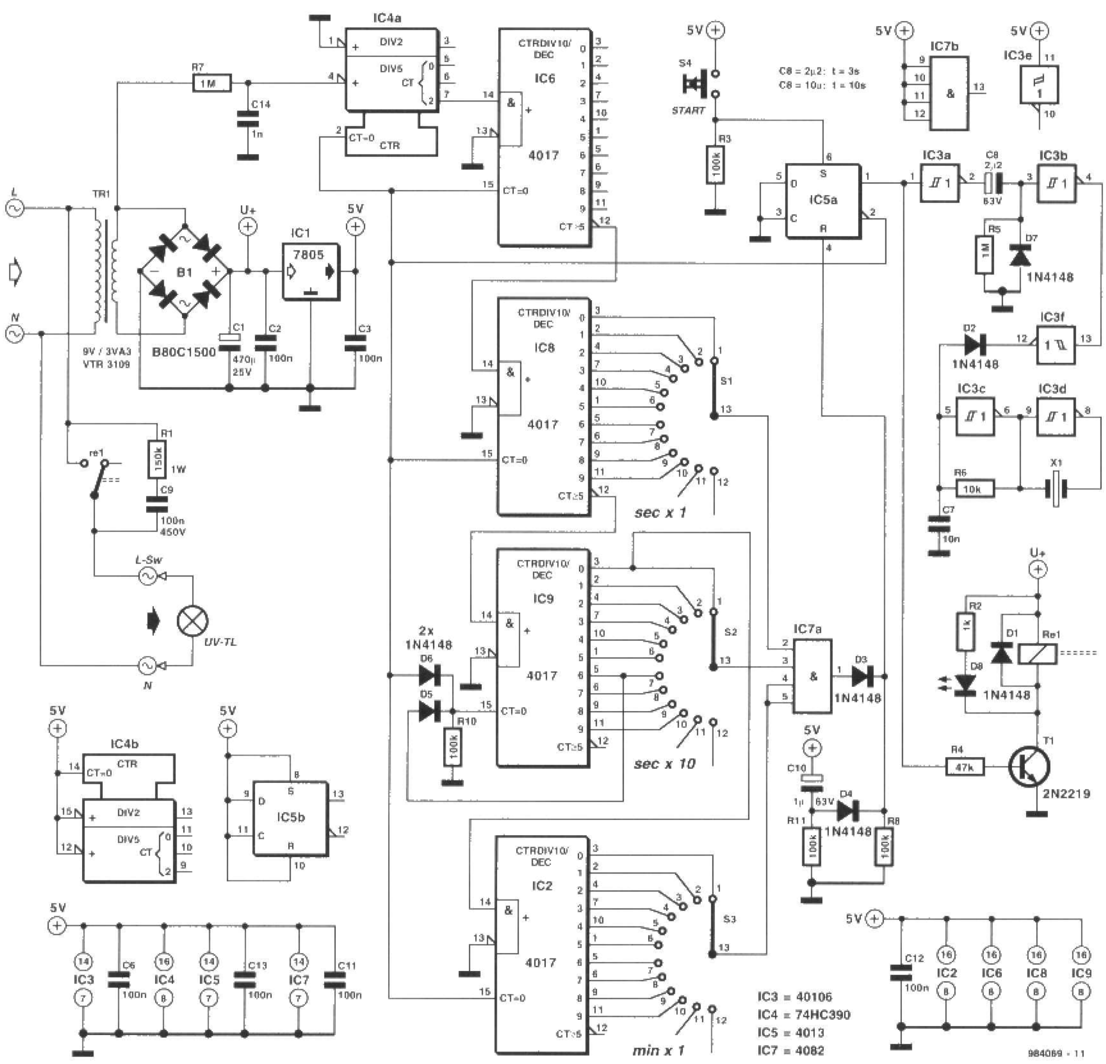


The 4047 used in the tester has a binary scaler at its output that guarantees symmetry.

The oscillator frequency is about 1 kHz. It may be powered from a 3–9 V source. Normally, this will be a battery, but a variable power supply has advantages. It shows at which voltage the display works satisfactorily and also that there is a clear relationship between the level of the voltage and the angle at which the display is clearly legible. The tester draws a current not exceeding 1 mA.

The test voltage must at all times be connected between the common terminal, that is, the back plane, and one of the segments. If it is not known which of the terminals is the back plane, connect one probe of the tester to a segment and the other successively to all the other terminals until the segment becomes visible. Note, however, that there are LCDs with more than one back plane. Therefore, if a segment does not become visible, investigate whether the display has a second back plane terminal. [984023]

015 exposure timer for UV light box



Design: R. Veltkamp

Although the timer was designed specifically for use with an ultra-violet-light box, it may, if course, be used for other purposes as well. Note, however, that the maximum time that can be set is 10 minutes with a resolution of 1 second.

The time is set with three selectors: S_3 for the minutes, S_2 for tens of seconds, and S_1 for seconds.

The frequency of the mains supply voltage is scaled down to 10 Hz by IC_4 (which means that the circuit can be used only with 50 Hz mains supplies).

When the supply voltage is switched on, a reset pulse is applied to bistable (flip-flop) IC_5 via C_{10} and D_4. This makes the Q-output of IC_5 high, so that counters IC_2, IC_4, IC_6, IC_8, and IC_9 are reset in the quiescent state.

When start button switch S_4 is pressed, IC_5 is set and its Q-output then energizes the relay via transistor T_1, whereupon the relay contacts switch on the light box.

At the same time, the level at the Q-output of IC_5 makes the reset inputs of all counter ICs low and counting commences. When the counter position set with S_1–S_3 is reached, the output of IC_7 goes high and bistable IC_5 is reset again. Its Q-output goes low, whereupon the relay is de-energized.

Simultaneously, an oscillator based on IC_3 is actuated and drives buzzer Bz_1 for about three seconds. If this time is found too short, it may be lengthened by increasing the value of capacitor C_8.

Optionally, a light-emitting diode may be connected in parallel with the relay to give an optical indication that the light box is switched on.

The circuit draws a modest current, so that a 2.3 VA mains transformer is specified is m ore than adequate.

[984069]

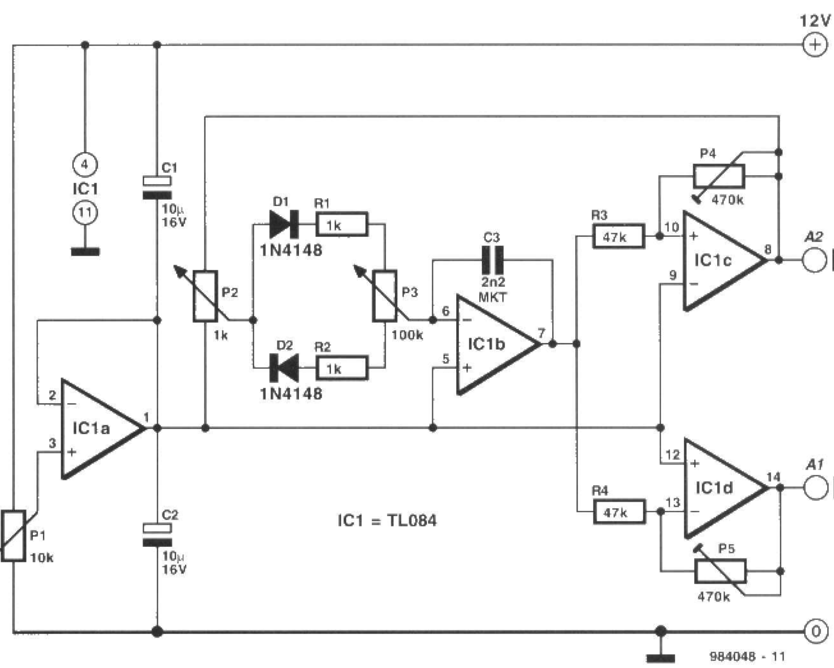
016 simple function generator

Brief parameters

- Provides triangle-wave, sawtooth or rectangular signal
- Waveform variable independently of frequency (triangle wave and sawtooth)
- Duty cycle of rectangular signal can be set independently of frequency

Applications

- Test and measurement
- Pulse-width control



Design: U. Kunz

Simple triangle-wave generators have a weakness in that the waveform of their output signal normally cannot be modified. The circuit presented here makes it possible to smoothly alter the waveform of a linearly rising and steeply trailing sawtooth signal through a symmetrical triangle-wave to a slowly trailing, steeply rising linear sawtooth. The wanted waveform may be selected independently of the frequency, which can also be varied uniformly from 0.2 Hz to 8 kHz. At the same time, a rectangular signal with variable duty cycle (also independent of frequency) is available at the rectangular-signal output of the circuit.

The circuit consists of integrator IC_{1b}, whose output is applied to comparator IC_{1c}. The output of the comparator is a rectangular signal

The output of IC_{1b} is raised by amplifier IC_{1d} to a level that allows the full output voltage range of the operational amplifier to be used.

Op amp IC_{1a} provides a stable virtual earth, whose level is set to half the supply voltage with P_1.

The smooth setting of the frequency is made possible by feedback of part of the output of the comparator to the input of the integrator via P_2. This preset is usually not provided in standard triangle-wave generators.

Network D_1-R_1-D_2-R_2-P_3 makes it possible to give integrator capacitor C_3 different charging and discharge times. This arrangement enables the output signal at A_1 and the duty cycle of the rectangular wave signal at A_2 to be varied.

Varying the amplification factor with P_5 has no effect on the frequency set with P_2.

The slope of the signal edges, the transient responses, and the output voltage range (rail-to-rail or with some voltage drop) depend on the type of op amp used. The TL084 used in the prototype offers a good compromise between price and meeting the wanted parameters.

The circuit is best built on a small piece of prototyping board.

The circuit draws a current of not more than 12 mA.

Summary of preset action:

P_1 – sets virtual earth to a level equal to $U_{cc}/2$;
P_2 – sets the frequency;
P_3– sets the waveform;
P_4 – sets the hysteresis of the comparator (frequency and amplitude of the triangle-wave signal)
P_5 – sets the amplification of the triangle-wave and sawtooth signals.

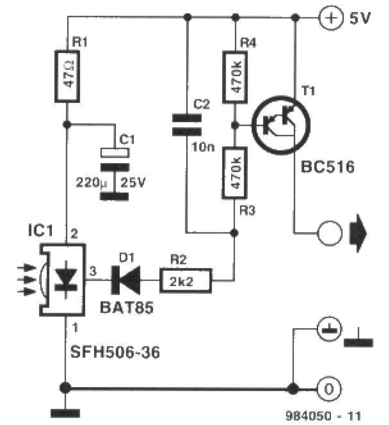
[984048]

017 infra-red receiver

Design: T. Giesberts

This very simple infra-red receiver is intended to form an infra-red remote control system with the simple infra-red transmitter described elsewhere in this issue.

The system does not use any kind of coding or decoding, but the carrier of the transmitter is modified in a simple manner to provide a constant switching signal. Since the receive module, IC_1, switches from low to high (in the quiescent state, the output is high) when the carrier is received for more than 200 milliseconds, the carrier is transmitted in the form of short pulse trains. This results in a pulse at the output of the receiver that has a duty cycle which is just larger than 12.5%. The carrier frequency used in the system is 36 kHz, so that the output frequency of IC_1 is 281.25 Hz. This signal is rectified with a time constant that is long enough to ensure good smoothing, so that darlington T_1 is open for as long as the received signal lasts.



A drawback of this simple system is that it may pick up signals transmitted by another infra-red (RC5) controller. In this case, only the envelopes of the pulse trains would appear at the output of T_1. This effect may, of course, be used intentionally. For instance, the receiver may be used to drive an SLB0587 dimmer. Practice has shown that the setting of the SLB0587 is not affected by the RC5 pulses.

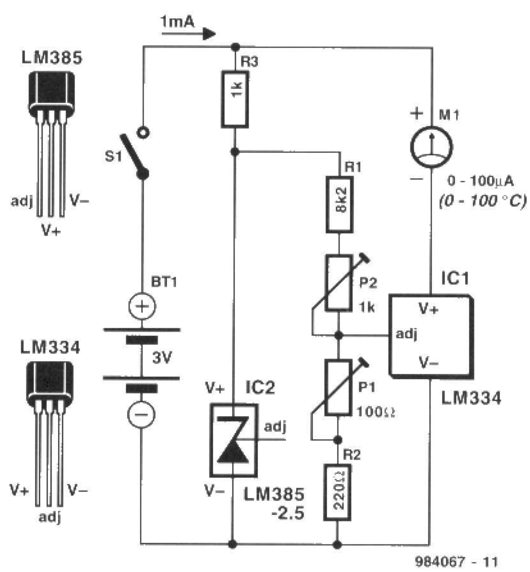
The receiver draws a current of about 0.5 mA. [984050]

018 Celsius thermometer

National Semiconductor Application

The circuit of the Celsius thermometer in the diagram is based on the well-known Type LM334 from National Semiconductor. This IC is a sensor that provides a current which is directly proportional to the temperature in kelvin (K). Unfortunately, this is a quantity that is not suitable for use in most practical applications. In the circuit, therefore, the sensor is set to 1 μA K^{-1} with P_1 and the offset of 273 K removed with P_2. This renders the output voltage of the sensor directly proportional to the temperature in degrees Celsius (° C) and this makes the circuit suitable for a great many applications (since 1 K = 1° C).

Circuit IC_2 is arranged as a 2.5 V reference voltage source. The current setting of the sensor is determined by the resistance between the adj(ust) pin and earth. If the earth is made virtual by raising the potential at the adj pin, the zero point can be shifted as desired.



Calibration is best done by using a good domestic thermometer as reference. Start by short-circuiting IC_2 and adjusting P_1 until the reading of meter M_1 shows a current value numerically equal to the ambient temperature plus 273. If, say, the room temperature is 25° C, adjust P_1 until the meter reads 298 μA. Then, remove the short-circuit from IC_2 and adjust P_2 until the meter reads a current whose numerical value is equal to the room temperature, that is, 25 μA.

The circuit draws a current not exceeding 1 mA, so using two AA size (AM3, MN1500, LR6, SP/HP7) batteries as power source will give a life of a couple of years.

[984067]

APPLICATION NOTE

ESD protection for I/O ports

Electrostatic discharge (ESD) can threaten an electronic system when someone replaces a cable or even touches an I/O port. Discharges that accompany these routine events can disable the port by destroying one or more of its interface ICs (see Figure 1). Such failures can also be costly—they raise the cost of warranty repairs while diminishing the product's perceived quality. These and other factors, coupled with the increasing amount of electrical communication between computers and computer-related equipment, lend emphasis to the need for engineers to understand ESD.

A Maxim Application

1

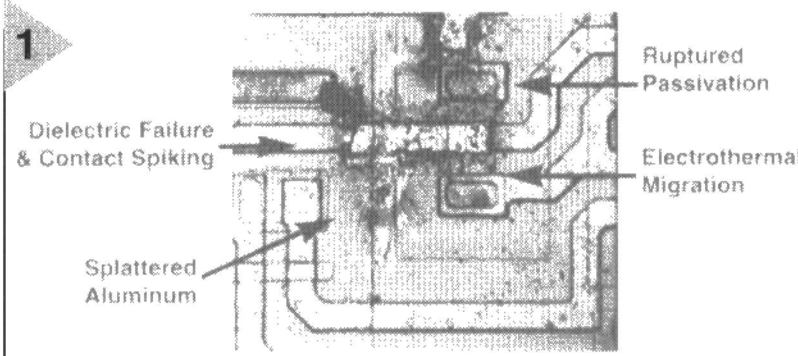


Figure 1. ICs with inadequate ESD protection are subject to catastrophic failure—inluding ruptured passivation, electrothermal migration, splattered aluminium, contact spiking, and dielectric failure.

ESD GENERATION

Electrostatic discharge appears when two dissimilar materials come together, transfer charge, and move apart, producing a voltage between them. Walking on a rug with leather soles, for example, can generate voltages as high as 25 kV. The level of electrostatic voltage induced depends on the relative charge affinity between rug and shoe leather, the humidity, and other factors.

ESD TEST METHODS

Two methods are commonly used for testing the ESD susceptibility of integrated circuits. The oldest, MIL-STD-833 Method 3015.7, was developed as an aid to understanding the precautions necessary for packaging and handling ICs. This method tests each package pin against other groups of pins, and classifies the device according to the lowest voltage for which failure occurs.

The applied signal in this test is a current waveform derived from a circuit called the human body model (see **Figure 2**), which simulates the capacitance and source impedance typical of a human body. Circuit layout is critical, because the actual waveform delivered at the IC depends also on parasitic inductance and capacitance associated with the test connections and PC board. The resulting current waveform represents the ESD that occurs when a person touches an object, such as an IC.

The other method, which differs from the above only in the values for R and C, was developed by the Electronic Industries Association of Japan (EIAJ). Called IC-121 and based on a circuit called the machine model, it applies a current waveform similar to that produced when an IC makes contact with its handling machinery. By mimicking the ESD events caused by charges that accumulate on moving parts, the waveform simulates static discharges seen during machine assembly.

The two methods are complementary, so you shouldn't choose one over the other. Because ESD can affect ICs during manufacturing, during PC board assembly, and after the end product is put into service, a test based on the human body model and the machine model together provides adequate assurance regarding the IC's tolerance to the rigours of manufacturing and insertion.

Some ICs, whose pins are exposed to the outside world through connectors, can encounter ESD even when mounted on a PC board within an enclosure. ESD exposure is less likely for the other pins, which are connected to circuitry on the board. For this class of IC, a test method such as 3015.7 (which tests pin combinations) does not provide an adequate representation of ESD susceptibility for the input/output (I/O) pins.

Both offer ratings according to the lowest-voltage failure on *any* pin—an approach that may not do justice to the higher levels of internal ESD protection required by the I/O pins (and provided by some manufacturers). A device might have I/O pins that withstand ±15 kV, for example, and non-I/O pins that fail at ±2 kV. With the methods stated, the device's ESD rating would

be less than ±2 kV. Fortunately, however, better test methods are now available for rating the I/O pins.

NEW ESD TEST FOR I/O PORTS

An I/O port allows communication with other pieces of equipment. I/O ports for ICs comprise logical groups of pins that give access to equipment external to the system that contains the IC. These pins are subject to static discharge and other abuse as operators connect and disconnect cables from the system. For the I/O pins of an RS-232 or RS-485 interface IC, an ideal test method for ESD susceptibility should:

- Test the I/O pins in ways that simulate exposure to ESD events in actual equipment.
- Apply test waveforms that model electrostatic discharges produced by the human body. Different circuit models specify different values of amplitude, rise/fall time, and transferred power.
- Test the IC with and without power applied.
- Define IC failures to include latchup (a momentary loss of operation), as well as catastrophic or parametric failure. Latchup is considered a failure mechanism because if left undetected, it can lead to reliability problems and system malfunctions.

Two methods—both compliant with the requirements listed—have seen increasing use by equipment manufacturers in testing the ESD susceptibility of I/O ports. The first is a modification of Method 3015.7, MIL. STD 883. It makes use of the same circuit model and waveforms as the original method, but applies ESD pulses only to the I/O pins of a device. Its intent is to simulate the fault currents seen by an IC installed on a board and operating in the target system.

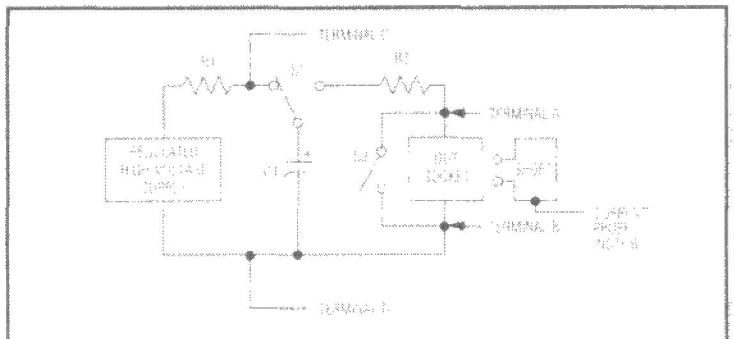
Like the original Method 3017.7, the modified method defines only an ESD waveform and the criteria for failure: after exposure to the waveform, a failed IC must either exhibit latchup or fail one or more data sheet specifications. The modified method stipulates no particular operating code for the IC during test..

Similarly, the modified method 3015.7 does not compel products to withstand particular levels of ESD; it only defines classes of protection. New transceivers from Maxim, however, generally provide protection levels to ±15 kV.

IEC 1000-4-2 MODEL

The second, more stringent, method for testing ICs that include I/O pins is IEC 1000-4-2. Originally intended as an acceptance condition for equipment to be sold in Europe, it is rapidly gaining acceptance as a standard criterion in the United States and Japan as well. Though not originally intended as an IC specification, it now does extra duty as an ESD test for ICs. Like the modification to 3015.7, it tests only the I/O pins.

2



COMPONENT	HUMAN BODY MODEL (MIL-STD 883, METHOD 3015.7)	MACHINE MODEL (IC-121, EIAJ)	IEC 1000-4-2
R1 (Ω)	1M–10M	1M	50M–100M
R2 (Ω)	1500 ± 1%	0Ω	330
C1 (pF)	100 ± 10%	200 ± 5%	150

Figure 2. Substituting different component values as shown yields discharge circuits known as the human body model, the machine model, and the IEC 1000-4-2 model (human holding a metallic object).

The model for IEC 1000-4-2 is again the circuit of Figure 2, but with different component values. Resistor R_2 represents a human holding a screwdriver or similar metallic object, and C_1 represents another estimate of human-body capacitance. This circuit produces a current waveform (**Fig-ure 3**) with a rise time steeper than that produced by Method 3015.7.

IEC 1000-4-2 specifies ESD testing both by contact discharge and by air discharge. ESD evens caused by actual contact are more repeatable but less realistic, and air discharge is more realistic but subject to wide differences in waveform shape—according to variations in temperature, humidity, barometric pressure, distance between IC and electrode, and rate of approach to the IC pin. This change of shape can have a significant effect on the measured level of tolerance for ESD.

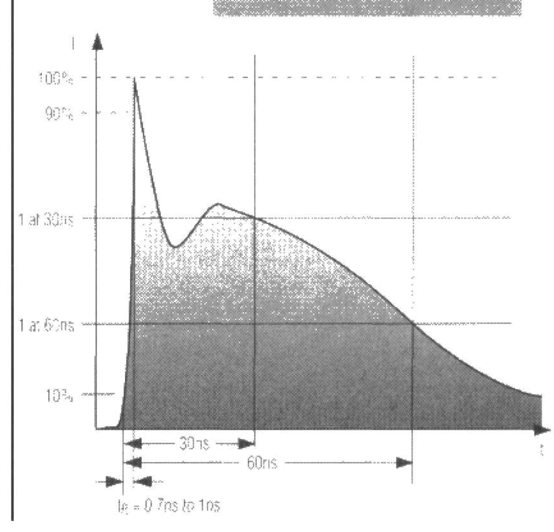
CONTACT OR AIR DISCHARGE?

Testing ICs for ESD ruggedness per IEC 1000-4-2 requires the use of an ESD 'gun', which allows testing with either contact discharge or air discharge. Contact discharge requires physical contact between the gun and the I/O pin before test voltage is applied by a switch internal to the gun. Air discharge requires the gun to be charged with test voltage before it approaches the I/O pin (from the perpendicular, and as quickly as possible). The second technique produces a spark at some critical distance from the test unit.

ESD produced by air discharge resembles actual ESD events. But, like actual ESD, the air-discharge variety is not readily duplicated. It depends on many variables that are not easily controlled. Thus, attesting to the general importance of repeatability in testing, IEC 1000-4-2 recommends contact discharge, and the modified 3015.7

3

Figure 3. Parameters for this ESD waveform (rise time, peak current, amplitude at 30 ns, and amplitude at 60 ns) are specified by IEC 1000-4-2.



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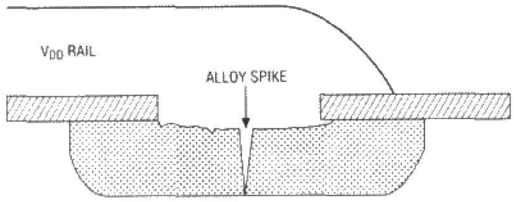

Figure 4. High-ESD current in an IC can 'spike' a junction by partially dissolving the aluminium contact in silicon, causing a permanent short to the layer below.

method requires contact discharge only. In either case, the test procedure calls for at least ten discharges at each test level.

The main difference between the two ESD standards just discussed is in the peak currents they produce in the device on test. Different component values can cause these peak currents to differ by a factor greater than five. Because peak currents produce the unwanted power that an IC must dissipate, IEC 1000-4-2 is usually the more demanding test method for ESD.

High current can damage an IC in various ways:

- Excessive local heating.
- Melted silicon.
- Spiked junctions, caused by a short that dissolves aluminium in the silicon (**Figure 4**).
- Damaged metal lines.
- Gate-oxide failure owing to excessive voltage.
- Transistor damage owing to electrothermal migration (**Figure 5**).

PROTECTION METHODS

To protect against ESD, a designer can either add the protection externally or choose ICs with high levels of protection built in. Protection circuitry includes metal-oxide varistors and silicon avalanche suppressors. These devices are effective but expensive. External ESD protection also takes up valuable board area and adds capacitance to the I/O line.

To overcome these limitations, manufacturers have repeatedly raised the level of ESD protection in their ICs. Maxim, for exam[le, now provides ±15 kV protection for RS-232 ICs, whether tested in accordance with IEC 1000-4-2 or the human body model.

RECOMMENDATIONS

An ESD current waveform is characterized by extremely fast rise times, so its progress through an IC is strongly affected by the circuit's distributed parasitic impedances. Therefore, attention to the external layout will ensure maximum performance by the ICs internal protection networks.

- Follow standard analogue layout techniques, placing all bypass (decoupling) and charge-pump capacitors as close to the IC as possible.
- Include a ground plane on the PC board.
- Minimize trace (track) inductance and capacitance.
- Place the IC as close to the I/O port as possible.

In testing, ensure that the test setup causes ESD currents to flow along the same paths as they would in that equipment. Step through the specified ESD range in increments of 200 V, and at each level provide the device ten times with each polarity of this voltage, about once per second. The voltage should be applied with respect to the IC's ground pin.

Check for failures by monitoring three parameters after each zap.

First, the supply current should remain constant (an increase may indicate latchup or internal damage).

Second, the transmitter output voltage should continue to meet the ±5 V minimum levels for RS-232 transmission.

Third, the receiver input resistance should remain between 3 kΩ and 7 kΩ (ideally, it should remain at a constant level in that range). Apply the voltage as described and test the device in all its modes: normal operation, shutdown, power off, transmitter high/low, and so on.

GUIDELINES FOR SELECTING ICS

The following questions should be resolved before choosing an IC (particularly an RS-232 transceiver) that must withstand high levels of ESD.

- *What level of ESD voltage is the IC guaranteed to withstand, and by what test method was that level established?* Different test methods yield different voltage ratings. Currently, the recommended approach includes both IEC 1000-4-2 and the modified 3015.7 method.
- *Will ESD cause latchup in the IC?* Latchup is a critical problem. The IC might stop functioning if ESD causes latchup in the circuit. The resulting supply current (as much as 1 A) may destroy the IC.
- *Does the IC's ESD protection affect normal operation?* Normal operation can cause latchup in the internal protection structure if it is poorly designed.
- *Must you observe special precautions when applying the IC?* Bipolar ICs might require expensive, low-ESR (equivalent series resistor) capacitors or a ground plane with low a.c. impedance. It's best to learn of these requirements at the outset.
- *What is the IC's maximum specified slew rate?* An IC susceptible to latchup because of its ESD-protection structure might specify an unusually low maximum slew rate to avoid triggering the latchup condition.
- *How does the IC respond to an ESD test that covers the entire range for which voltage protection is guaranteed?* Trigger mechanisms for an ESD-protection structure can kick in at different voltage ranges, leaving open 'windows' with no protection. Such a device might survive ±10 kV, but fail at ±5 kV, for instance. That is why it is recommended that an ESD test covers the entire range in 200 V increments.

[984101]

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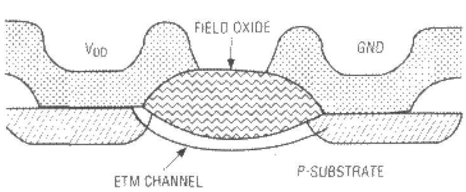
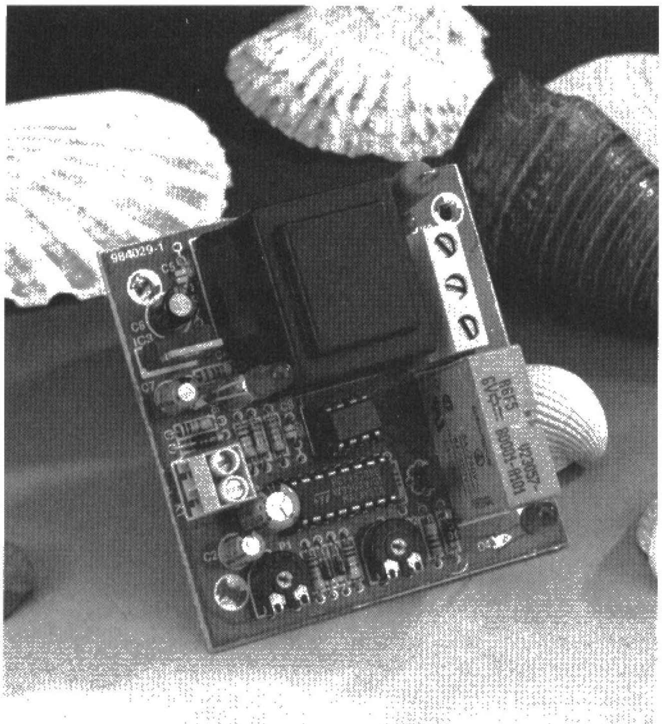


Figure 5. Electrothermal migration (ETM) in an IC can set the stage for damage in the presence of an ESD event. The resulting high current and high voltage can cause a short circuit or low-impedance path between the terminals of a transistor.

019

doorbell-controlled burglar deterrent light



Design: K. Walraven

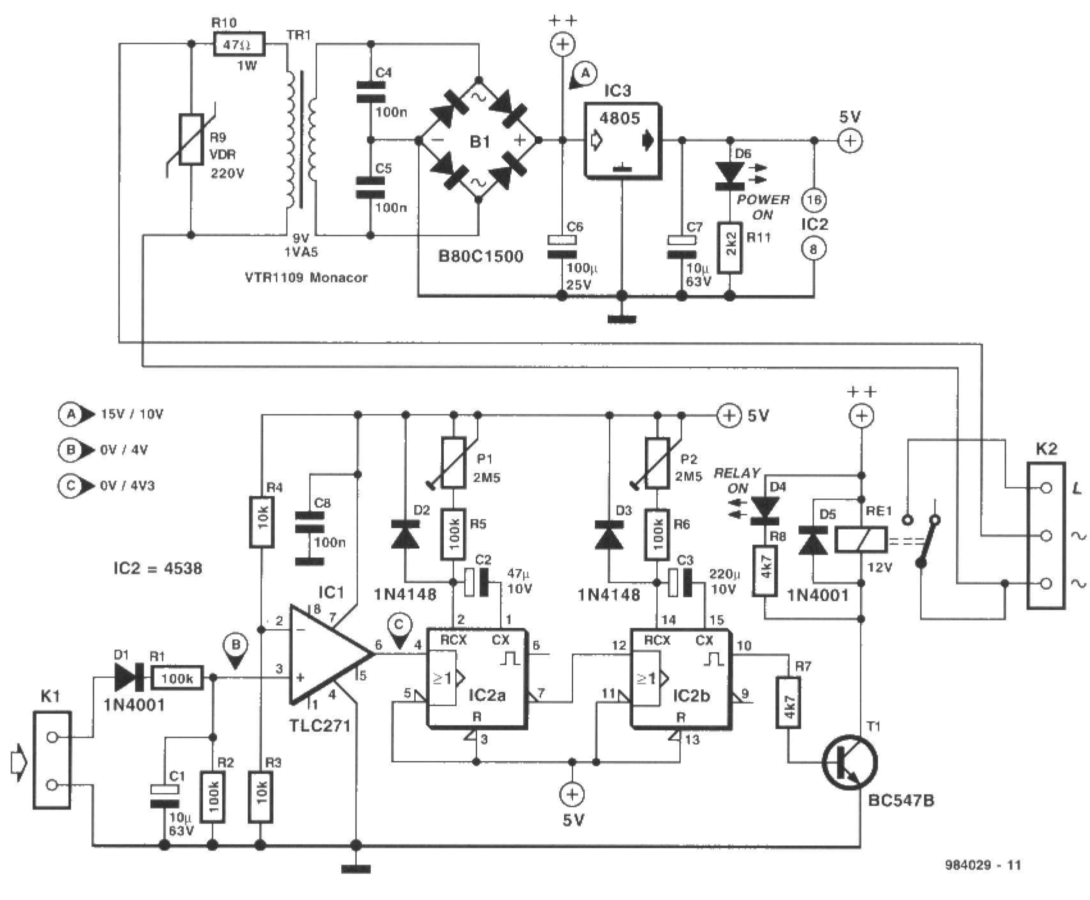
One obvious, perfectly normal and socially accepted way of seeing if somebody is at home is to ring the doorbell. Unfortunately, burglars also employ the very same doorbell to see if you are *not* at home! This circuit, we hope, will trick potential burglars into believing that someone is about to answer the door by turning on a lamp after a short delay. The length of the delay is adjustable between about 5 and 125 seconds. Likewise, the 'on' time of the lamp is adjustable between 25 and 600 s.

The circuit was designed for easy connection to an existing doorbell switch, provided this is part of a common-or-garden 8-volt AC or DC doorbell circuit. The input of the circuit is simply connected in parallel with the doorbell switch. A relay is used at the output of the circuit so that a lamp, exterior or in the hallway, is easily connected up. Pressing the doorbell causes capacitor C1 to be charged to a level exceeding the 2.5-V switching threshold set up for comparator IC1. As a result, the comparator output swings high and triggers monostable multivibrator (MMV) IC2a. This MMV determines the time (delay) it takes before the lamp is switched on. This delay is adjusted with preset P1. The next MMV, IC2b, is used to create the 'lamp-on' period, which is also adjustable (P2). An indicator LED, D4, is provided to check the relay activity.

The only unconventional thing about the power supply is that it exploits the fact that the small 9-volt transformer easily supplies 15 volts. This circumstance should allow a low-power 12-volt relay to be used without problems, the unregulated voltage dropping to about 10 V when the relay pulls in.

In case the doorbell voltage is smaller than about 8 volts, the value of R1 may have to be decreased. If the doorbell is DC-controlled, then the + connection of the doorbell switch should go to the anode (+ side) of D1. Here, too, the value of R1 may be decreased if necessary.

The circuit board is designed for incorporation into a mains adaptor enclosure from Micro. Due attention should be given to the connection of the wiring between terminal block K2 and the mains socket in the case. Be sure to use only mains-rated



COMPONENTS LIST

Resistors:
R1,R2,R5,R6 = 100kΩ
R3,R4 =10kΩ
R7,R8 = 4kΩ7
R9 =VDR 220V (UK: 240V), small model
R10 =47Ω 1W
R11 = 2kΩ2
P1,P2 = 2MΩ5 preset H

Capacitors:
C1,C7 = 10μF 63V radial
C2 = 47μF 10V radial
C3 = 220μF 10V radial
C4,C5,C8 = 100nF
C6 = 100 μF 25V radial

Semiconductors:
B1 = B80C1500, rectangular case, negative (–) terminal at bevelled edge (80V piv, 1.5A cont.)
D1,D5 = 1N4001
D2,D3 = 1N4148
D4,D6 = LED 5mm
T1 = BC547B
IC1 = TLC271CP
IC2 = 4538
IC3 = 4805

Miscellaneous:
K1 = 2-way PCB terminal block, pitch 5mm
RE1 = Card relay E, 12V, 1 make contact, type V23057-B0002-A401 (Siemens)
K2 = 3-way PCB terminal block, pitch 7.5mm
TR1 = mains transformer, 9V 1.5VA, VTR1109 (Monacor/Monarch*)
Case: Micro type N12
PCB, order code 984029-1
* No UK distributor(s), item available through C-I Electronics or Stippler Electronics.

wires, and properly secure the ends on the PCB terminal block and the mains plug/socket combination. Also with electrical safety in mind, the LED should not protrude any further from the case than strictly required. The printed circuit board shown here is available ready-made through the Publishers.

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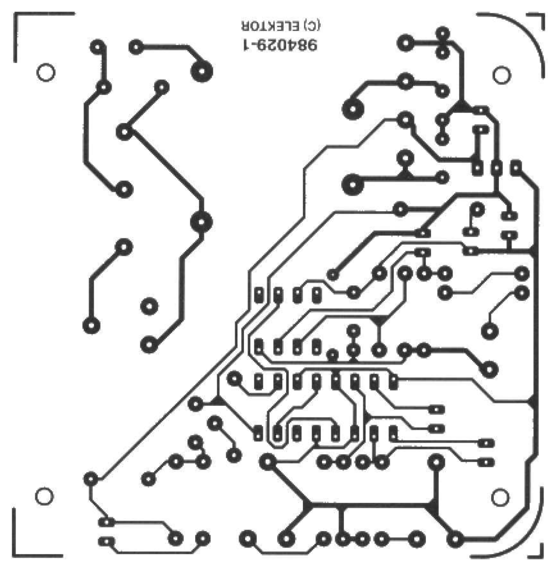
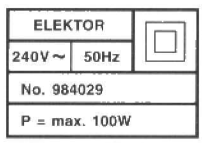
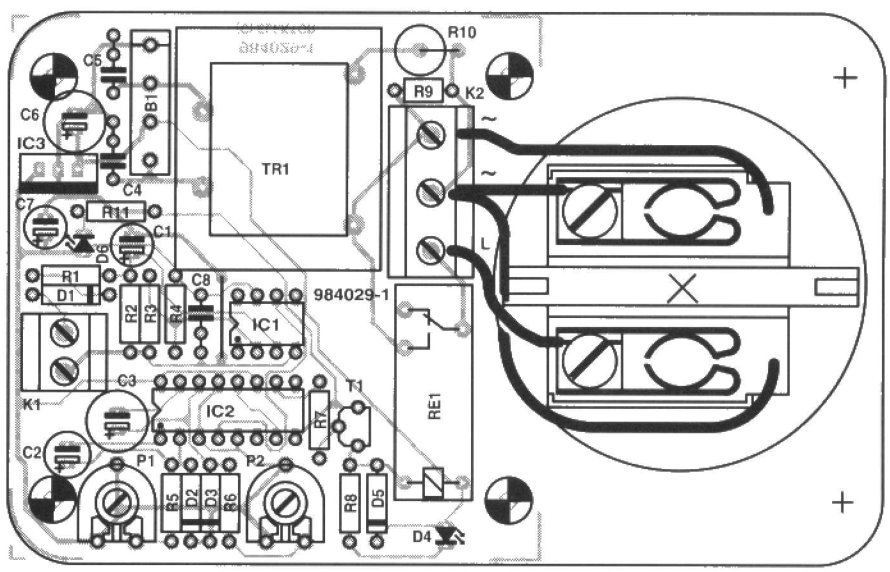




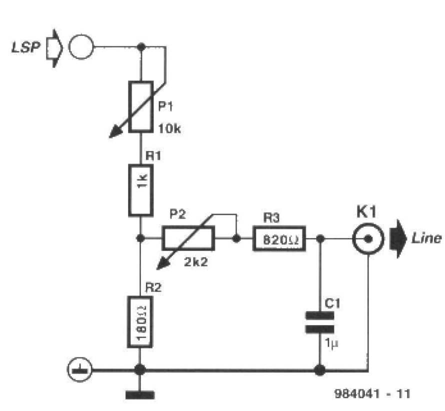


020 crossover for subwoofer

Design: T. Giesberts

The crossover network is intended for use when an existing audio installation is to be extended by the addition of a subwoofer. Often, this additional loudspeaker is one that has been lying around for some time. If its frequency response extends down far enough, all is well and good, but a filter is then needed to cut off any frequencies above, say, 150 Hz.

Often, a subwoofer network is an active filter, but here this would necessitate an additional power supply. The present network is a passive one, designed so that the speaker signal of the existing system can be used as the input signal. Since the bass information is present in both (stereo) loudspeakers, the signal for the sub woofer can simply be tapped from one of them.



The network is a 1st order low-pass filter with variable input (P_1) and presettable cut-off frequency (P_2).

The signal from the loudspeaker is applied to terminal 'LSP'. Voltage divider R_1-R_2-P_1 is designed for use with the output signal of an average output

amplifier of around d 50 W.

The crossover frequency of the network may be varied between 50 Hz and 160 Hz with P_2. The values of R_3, P_2, and C_1, are calculated on the assumption that the subwoofer amplifier to be connected to K_1 has a standard input resistance of 47 kΩ. If this figure is lower, the value of C_1 will need to be increased slightly.

It is advisable to open the volume of the subwoofer amplifier fully and adjust the sound level with P_1. This ensures that the input of the subwoofer amplifier cannot be overloaded or damaged.

Make sure that the ground of the loudspeaker signal line is linked to the ground of the subwoofer amplifier. If phase reversal is required, this is best done by reversing the wires to the subwoofer.

If notwithstanding the above additional protection is desired at the input of the subwoofer amplifier, this is best effected by 'overload protection' elsewhere in this issue. [984041]

021 electrical isolation for I²C bus

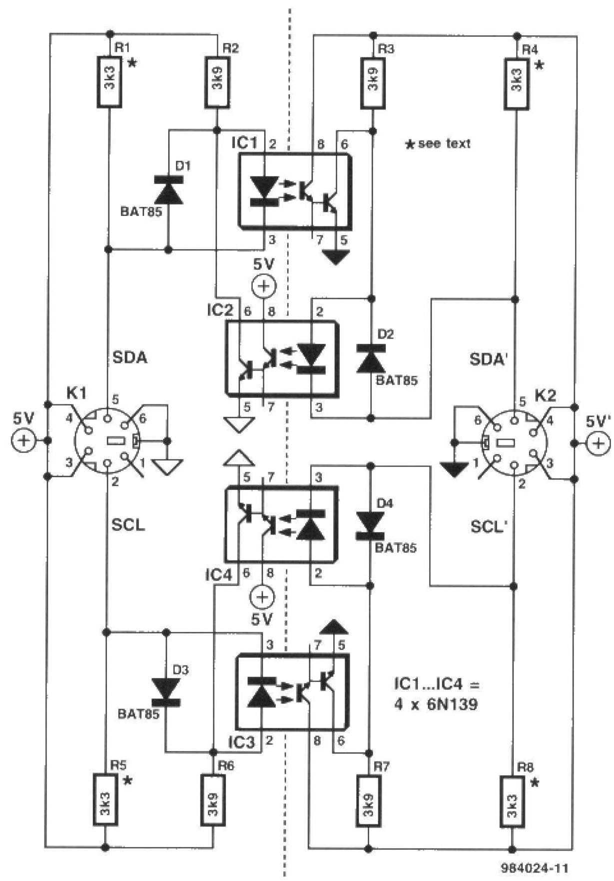
National Semiconductor Application

When the SDA (Serial DAta) lines on both the left and right lines are 1, the circuit is quiescent and optoisolators IC_1 and IC_2 are not actuated. When the SDA line at the left becomes 0, current flows through the LED in IC_1 via R_2. The SDA line at the right is then pulled low via D_2 and IC_1. Optoisolator IC_2 does not transfer this 0 to the left, because the polarity of the LED in IC_2 is the wrong way around for this level. This arrangement prevents the circuit holding itself in the 0 state for ever.

As is seen, the circuit is symmetrical. So, when the SDA line at the right is 0, this is transferred to the left.

The lower part of the diagram, intended for the SCL (Serial CLock) line, is identical to the upper part.

Resistors R_1, R_4, R_5, and R_8, are the usual 3.3 kΩ pull-up resistors that are obligatory in each I²C line. If these resistors are already present elsewhere in the system, they may be omitted here.



The current drawn by the circuit is slightly larger than usual since the pull-up resistors are shunted by the LEDs in the optoisolators and their series resistors. Nevertheless, it remains within the norms laid down in the I²C specification. [984024]

022 mini audio signal generator

Design: T. Giesberts

A small audio test generator is very useful for quickly tracing a signal through an audio unit. Its main purpose is speed rather than refinement. A single sinewave signal of about 1 kHz is normally all that is needed: distortion is not terribly important. It is, however, important that the unit does not draw too high a current.

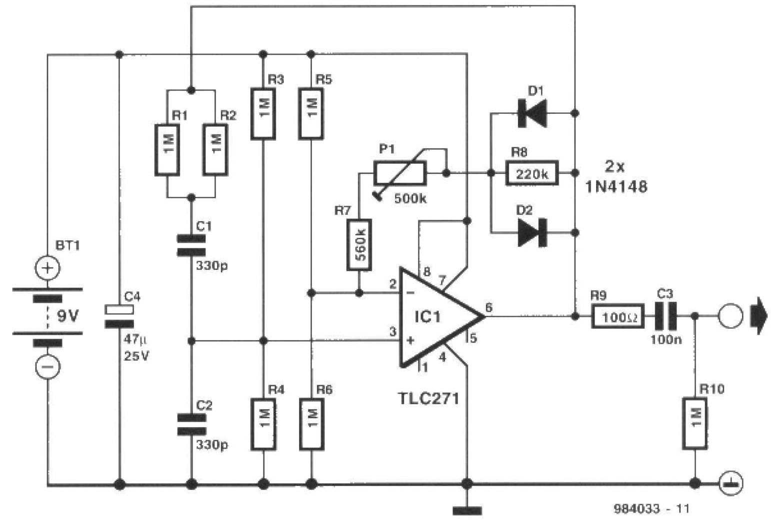
The generator described meets these modest requirements. It uses standard components, produces a signal of 899 Hz at an output level of 1 V r.m.s. and draws a current of only 20 μA. In theory, the low current drain would give a 9 V battery a life of 25,000 hours.

The circuit is a traditional Wien bridge oscillator based on a Type TLC271 op amp. The frequency determining bridge is formed by C_1, C_2 and R_1–R_4. The two inputs of the op amp are held at half the supply voltage by dividers R_3-R_4 and R_5-R_6 respectively. Resistors R_5 and R_6 also form part of the feedback loop. The amplification is set to about ×3 with P_1.

Diodes D_1 and D_2 are peak limiters. Since the limiting is based on the non-linearity of the

diodes, there is a certain amount of distortion. At the nominal output voltage of 1 V r.m.s., the distortion is about 10%. This is, however, of no consequence in fast tests. Nevertheless, if 10% is considered too high, it may be improved appreciably by linking pin 8 of IC_1 to ground. This increases the current drain of the circuit to 640 μA, but the distortion is down to 0.7%, provided the circuit is adjusted properly. If a distortion meter or similar is not available, simply adjust the output to 1 V r.m.s.

Since the distortion of the unit is not measured in hundredths of a per cent, C_1 and C_2 may be ceramic types without much detriment. [984033]



023 ultra-low-power 5 V regulator

Design: T. Giesberts

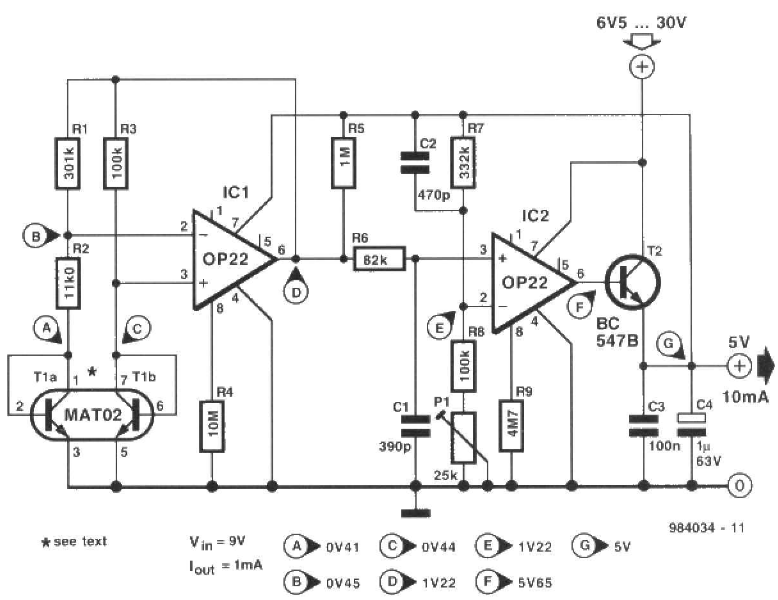
The current drain of the regulator is minute compared with that of, say, a 78L05: at an input voltage of 9 V and open-circuit output, it is just under 50 μA.

The circuit consists of a straightforward bandgap reference based on T_1 and IC_1, followed by an amplifier formed by IC_2 and T_1.

The reference voltage is about 1.22 V, which is raised by IC_2 to 5 V. The output voltage can be set to exactly 5 V with P_1. The input voltage may lie between 6.5 V and 30 V. The maximum output current with the present configuration and component values as specified is about 10 mA.

For optimum performance, T_{1a} and T_{1b} need to be identical, which is why a dual transtor Type MAT02 is used. Other types that may be used are the MAT01, SSM2210 or LM394. In principle, two standard BC transistors may be used, provided they are selected for identical threshold voltage.

Circuits IC_1 and IC_2 are programmable op amps Type OP22. In the case of IC_2 this has the benefit that the peak output current can be set readily by altering the supply current to the op amp with R_9. The level of the current may be between 500 nA and 400 μA. Bear in mind that a larger output current requires the use of a more highly rated output transistor.



Filter R_6-C_1 prevents any spurious pulses reaching the input of IC_2. Capacitor C_2 improves the stability of the regulator, particularly with maximum pulse loading.

Note that the circuit has a high resistance, so that it is advisable to house it in a screened enclosure to prevent undesired magnetic and electromagnetic interference being coupled to the circuit.

The regulator was tested with a direct load current of 1 mA on which was superimposed a square-wave current of 10 mA. The test results are summarized in the table, in which I_g represents the current drawn by the circuit.

Table 1

V_{in} (V)	I_g (μA)	V_{out} (V)	V_{ripple} (mV_{rms})
7	43	5.002	110
9	49	5.002	100
15	68	5.002	70
30	123	5.002	50

[984034]

Portable Power from a Matchbox

Merlin Equipment's new NOTEpower 75i inverter allows people to run and recharge notebook computers, camcorders, mobile telephones and video games in their car.

By simply and silently converting the car's 12 volt battery power to 230 VAC mains electricity, people have enough power to run all day without the need to buy expensive spare battery packs! Even today's high-tech notebook computers and camcorders will last for just a few hours when running from their internal battery. By using the new matchbox size NOTEpower 75i, you never need to worry about short battery life again.

Specifically designed for operating electronics by a leading computer manufacturer, the NOTEpower is safe to use with most appliances available on the market. Supplied with a cigar lighter plug, the NOTEpower 75i simply plugs into the car cigar lighter socket for easy connection. Output is then available from the standard socket on the side of the unit.

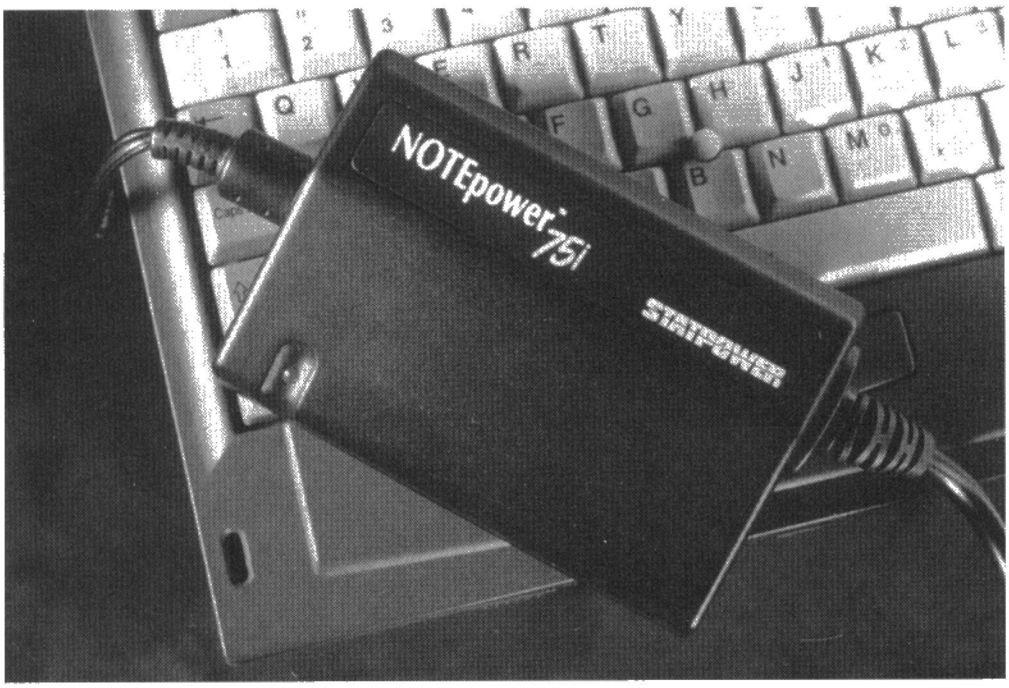
As well as giving notebook computers or camcorders indefinite battery life, the NOTEpower 75i can also be used to power peripherals such as tape recorders or bubblejet printers.

Fully overload and overheat protected, the NOTEpower 75i inverter employs state-of-the-art electronics to provide a power source which is more than 90% efficient, thus making best use of the vehicle's battery power. The unit is smaller, lighter and easier to use than any other on the market. Useful features such as a battery alarm will warn that the vehicle's battery is low and turns the inverter off to allow re-starting of the car.

NOTEpower 75i has a wide range of other useful applications, for example running chargers for small power tools, test equipment or complete mobile offices in cars, vans, boats or remote homes.

The NOTEpower 75i is CE approved, conforming to EU directives for electrical interference and safety, allowing the unit to be confidently used in many applications involving sensitive electronics.

Part of the PROwatt range of DC and AC power inverters, the NOTEpower 75i is the smallest in the range which boasts units capable of providing up to 2500 watts of power. Retail price for the unit is around £86 excluding VAT and carriage.



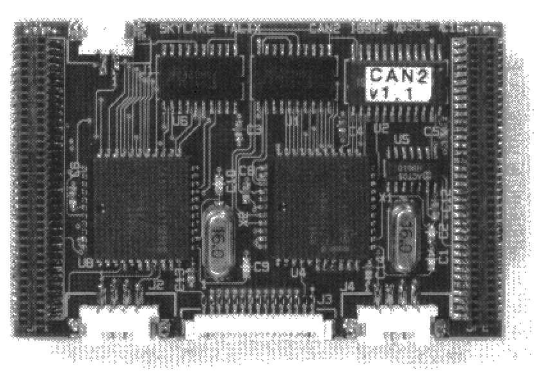
Merlin Equipment, Unit 1, Hithercroft Court, Lupton Road, Hithercroft Industrial Estate, Wallingford, Oxfordshire OX10 9BT. Tel. (01491) 824333, fax (01491) 824466.

(987004)

Credit Card Sized CANbus Interface

A new dual-channel CANbus interface is claimed to extend opportunities for ultra-compact distributed automation, while supporting CAN 'A' and CAN 'B' protocols for backwards compatibility.

Skylake Talix has introduced an extremely compact dual-channel CANbus interface suitable for a wide variety of industrial control and automotive applications. Dual high performance CAN controller chips on this sub credit card-sized module support standard and extended CAN protocols, ensuring compatibility with all existing CAN standards, while the high level software library significantly



shortens the development cycle. When combined with Talix' i386EX PC boards, engineers can create highly economic distributed real-time control solutions for applications where installation space is at a premium.

At the heart of the new interface are two Intel 82527 CAN Controller chips, each capable of supporting both standard CAN 2.0A and extended CAN 2.0B protocols at data rates up to 1 Mbit/s with very low bit error rate. Utilising two separate controller chips enables the interface to support dual independent networks, increasing its application flexibility.

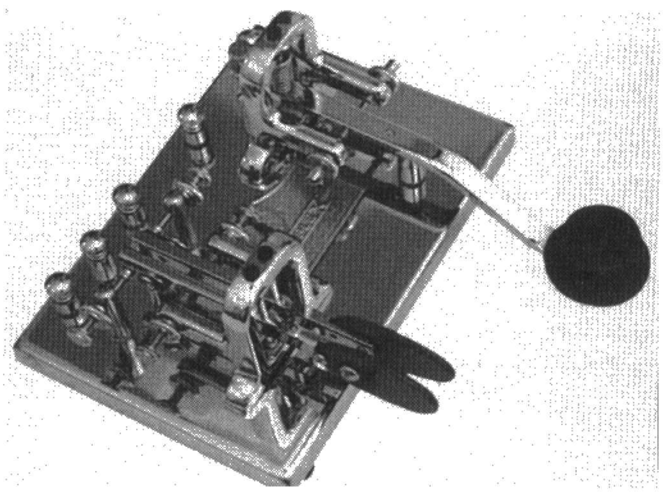
Talix' CANbus interface is priced at just £150 and the associated i386EX computer board at £175, making a highly economic combination for many embedded industrial control applications. Prototyping these embedded applications is made significantly more economical with the i386 development board priced at just £175.

Skylake Talix, Unit 3, Lulworth Business Centre, Nutwood Way, Totton, Southampton SO4 3WW. Tel. (01703) 666403, fax (01703) 663730. Internet: www.talix.co.uk

(987005)

Vibroplex Double Keys

By popular request, Vibroplex has combined its fabulous Straight Key with the classic Vibrokeyer or the Iambic on a massive steel base.



The new Double Keys have the famous brass Vibroplex logo plate with a unique serial number, making them the latest Vibroplex Collectibles. The Double Key allows the operator to instantly switch from using an electronic keyer to the personal touch of a Straight Key.

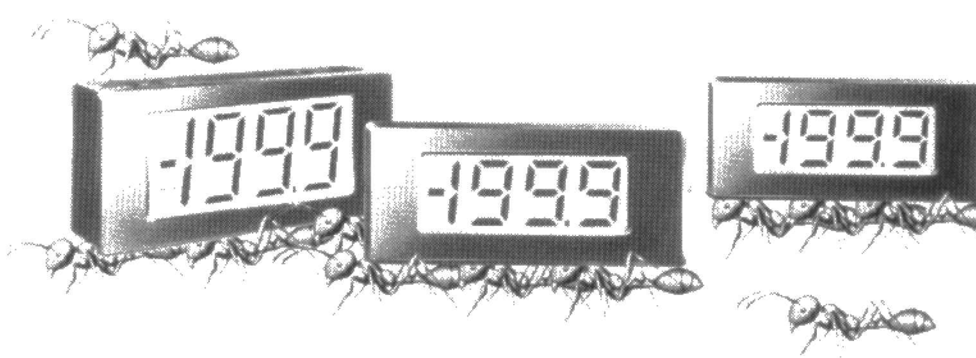
As with all Vibroplex keys, the machined Double Key parts are made on a digital milling machine with an accuracy of one thousandth of an inch or less. This precision in the manufacturing process, along with the careful assembly by Vibroplex's skilled technicians ensures that you will get a lifetime of use from your Double Key. The first keys manufactured will have consecutive serial numbers. Orders will be filled on a 'first come – first served' basis so the early orders will get low serial numbers. And of course, as with all of the Vibroplex keys, the Double Keys are manufactured in the USA. Vibroplex, 'the oldest name in ham radio'™, can trace its beginnings to 1890. Vibroplex manufactures a full line of Morse keys, including the famous 'Bug'. Vibroplex is owned by Felton 'Mitch' Mitchell, W4OA, who is celebrating his 34th year as an active ham.

The Vibroplex Co., Inc., 11 Midtown Park, E., Mobile, AL 36606-4141, USA. Tel. (334) 478-8873, fax (334) 476-0465.

(987006)

Snap-in Microminiature Panel Meters

The DPM 1, DPM 2 and DPM 3 are part of a family of snap-in micro-miniature panel meters from Lascar Electronics.



Accurate and reliable measurements can now be incorporated into even the most compact instruments, with digit heights ranging from 5.5mm to 11mm.

All three modules operate from a 9V supply, and feature auto-polarity, auto-zero, 150μA current consumption and 200 mV full-scale reading. A socket strip is provided to facilitate final assembly within the target instrument. Single rail 5V versions, allowing measurements referenced to power supply ground, are also available.

Applications include personal gas monitors, low-cost handheld instruments and other products where space is at a premium.

Lascar Electronics Ltd., Module House, Whiteparish, Salisbury, Wiltshire SP5 2SJ. Tel. (01794) 884567, fax (01794) 884616.

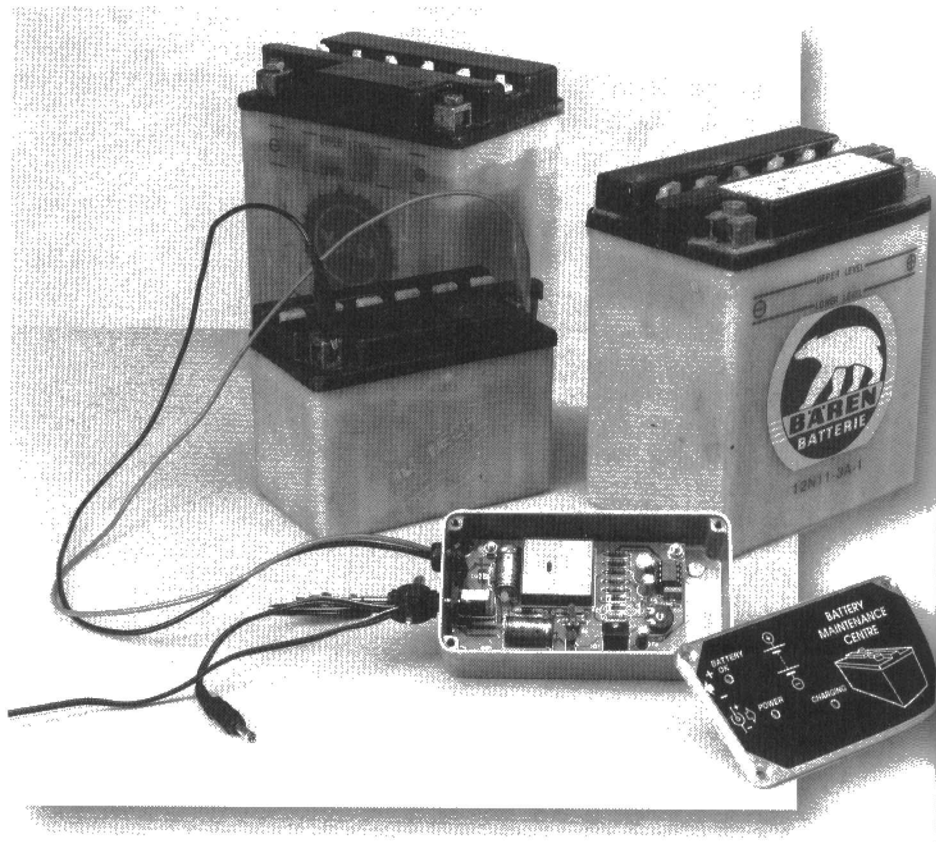
(987007)

maintenance charger

for 6 V and 12 V lead-acid batteries

If there is one thing that a lead-acid battery does not like it is persistent neglect. When such a battery is being discharged, its energy is produced by the acid in the electrolyte gradually combining with the active material of the plates. This combination produces lead sulphate in both negative and positive plates. A cell is completely discharged when both plates are entirely sulphated. Since the plates are then (irreversibly) composed of identical material the terminal voltage collapses. In normal practice, discharging would be stopped long before this condition is reached.

Design by K. Walraven



When a lead-acid battery used for starting a motorcycle or car is charged and discharged regularly it will not easily become deep-discharged since it is constantly being recharged by the alternator (or, in very old vehicles, the dynamo). This is, of course, true only if the vehicle is used regularly.

If the battery is not cycled regularly, it deteriorates more and more rapidly. This is quite clear from the chemical reaction formulas in the box. If you are not familiar with such formulas, they show, simply, that the acid in the electrolyte gradually combines with the active material of the plates. This combination produces lead sulphate ($PbSO_4$) in the plates. When discharge is allowed to continue, the plates will soon become entirely sulphated, a process that is, unfortunately, irreversible.

LONG-TERM STORAGE

It is sometimes unavoidable for a lead-acid battery to be put into cold storage, for instance, when the car or motorcycle is laid up for the winter. How can the battery then be saved from the fate just described?

If the battery is new or in very good condition, it may be sufficient to cycle (charge/discharge) it a couple of times and then store it at room temperature (about 20 °C). However, this is a risky thing to do even with a new(ish) battery, let alone with an older one, and certainly so if the period of non-activity is likely to be extended. This is because batteries all suffer from self-discharge, which causes a fully charged battery to become flat within a few months.

The only sure way of preventing a battery to be ruined in that situation is to ensure that it is charged regularly.

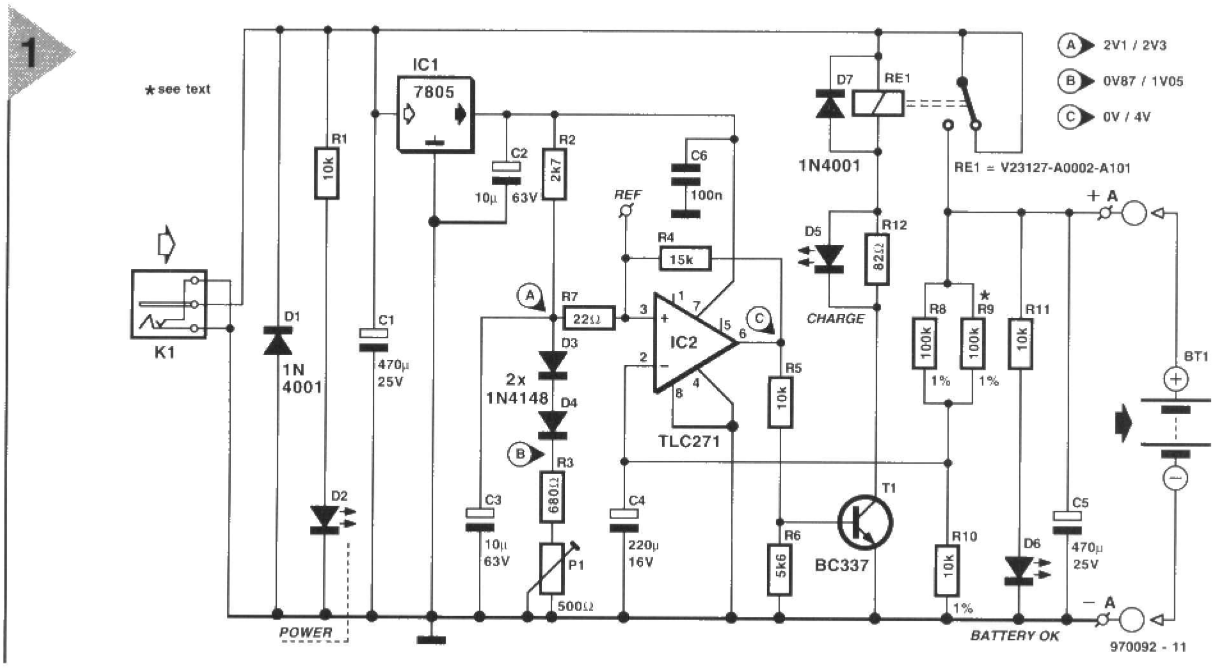


Figure 1. Circuit diagram of the maintenance charger, which is powered by a standard 6 V or 12 V mains adaptor connected to socket K_1.

This has to be done in an intelligent way, however, because overcharging is almost as bad as deep-discharging.

This means that a standard battery charger cannot be used, because it delivers such a large current that the battery needs to be charged for limited periods only. Such a charger can be used only in conjunction with a timer. Another way is, of course, to constantly trickle-charge the battery.

The present maintenance charger combines the functions of a standard charger and timer to monitor and replenish the charge of the battery.

MONITORING AND CHARGING

Although trickle-charging is a good alternative to the method described in this article, it has a few draw-backs. One of these is that the charging current has to be set very accurately, and another that it cannot charge a flat battery, which means that the procedure has to be started with a fully charged battery.

Although there are various ways of designing a maintenance charger, One of the most frequently used is based on an accurate voltage source that delivers a voltage equal to the end-of-charge voltage of the battery. In the case of a 12 V battery, this is usually taken as 13.8 V.

There are people who do not think this is a sufficiently safe method, since there is the (theoretical) risk that permanent connection to a fixed voltage may in the long run lead to an overcharge, however slight this may be. This may, however, be prevented by discharging the battery at regular intervals. It should be borne in mind, though, that this cycling does age the battery.

This ageing can be prevented, and the battery held properly charged at all times by the method used in the present charger. In this, the battery is charged to a certain potential, whereupon the charger is switched off. When the battery e.m.f. has dropped to an appreciably lower level, the charger is switched on again. When this process is continued, and provided the switch-over voltages are well selected, the charger is perfectly suited to maintaining the battery. It can, of course, also be used as a standard battery charger.

The above assumes that the charger has a facility for monitoring the battery voltage constantly and accurately. After all, this voltage is a guide to the state of charge.

The nominal voltage of a lead-acid cell is about 2 V, which does not depend on the number of plates or their capacity. When charging is commenced, there is an immediate rise in the cell voltage. When this voltage reaches a level of about 2.3 V, there is a fairly sharp rise, followed a little later by a levelling off, after which there is no further increase. Recharge of a cell is complete when the voltage and relative density of the electrolyte remain constant for about 3 hours.

In case of a 12 V battery, the above means that charging should commence when the e.m.f. of the battery is about 12.5 V and finish when the e.m.f. reaches a level of about 13.8 V. In the present charger, these switch-over points are adopted. Moreover, these points are temperature-compensated to preclude under-charging or overcharging owing to temperature variations.

CIRCUIT DESCRIPTION

The circuit in **Figure 1** may be split into two sections: the charger proper, and the monitoring and control network.

Power is supplied via a standard, unregulated 12 V mains adaptor rated at 1 A The adaptor is linked to jack K_1 and charges battery Bt_1 via the contact of relay Re_1. This is possible, because the average 12 V mains adaptor provides an e.m.f. of 17–18 V, which is more than enough to charge a battery to 13.8 V. Moreover, such an adaptor is inexpensive and safe, and its internal resistance provides automatic limiting of the charging current. For instance, the charging current from a 1 A adaptor at 12.3 V is 700 mA and at 13.8 V only 400 mA. In other words, when the charging voltage increases, the charging current drops. This is excellent, because at higher voltages the battery can be charged less and less.

The electronic networks ensure that charging is started and stopped at the correct times. A hysteresis of 1.2 V has been provided, which means that charging continues until the battery voltage is 13.8 V, whereupon the relay switches off the charging current. When the battery voltage drops to about 12.6 V, the charging current is switched on again. In practice, this means that charging lasts only a few minutes, while the intervals between consecutive charges amount to a couple of hours.

The monitoring and control circuit is based on operational amplifier IC_2, which is arranged as a comparator with hysteresis. This IC compares part of the battery voltage with a preset reference voltage. Depending on the result, the level at the output of the IC causes relay Re_1 to be energized or not via transistor T_1.

In the comparison, the e.m.f. of one cell of the battery is used. The accurate

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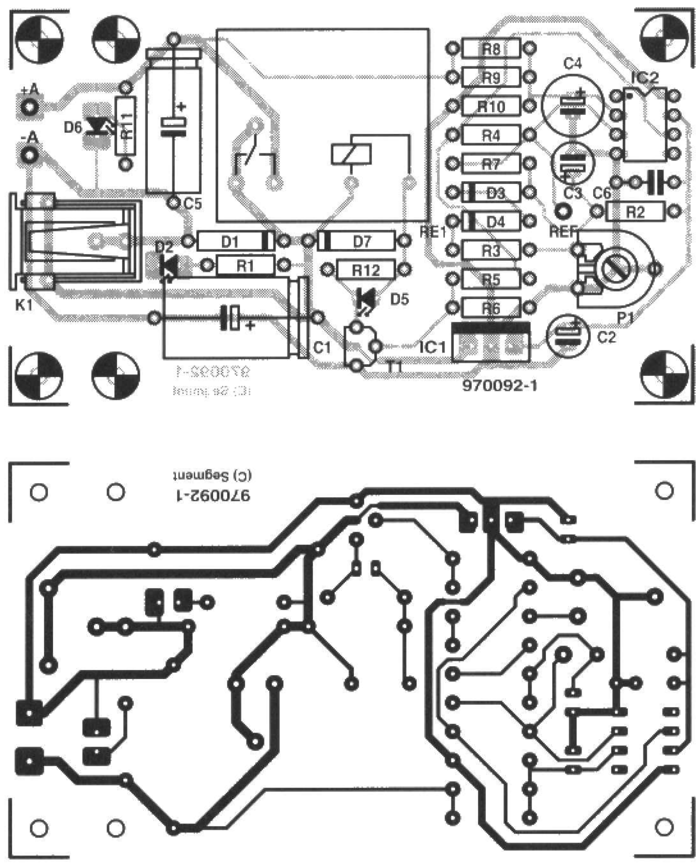

Part list

Resistors:
R_1, R_{11} = 10 kΩ (12 V) or 3.9 kΩ (6 V)
R_2 = 2.7 kΩ
R_3 = 680 Ω
R_4 = 15 kΩ
R_5 = 10 kΩ
R_6 = 5.6 kΩ
R_7 = 22 Ω
R_8 = 100 kΩ (12 V) or,20 kΩ (6 V), 1%
R_9 = 100 kΩ (12 V), 1%; not used (6 V)
R_{10} = 10 k=, 1%
R_{12} = 82 Ω
P_1 = 500 Ω, preset potentiometer

Capacitors:
C_1, C_5 = 470 μF, 25 V
C_2, C_3 = 10 μF, 63 V, radial
C_4 = 220 μF, 16 V, radial
C_5 = 220 μF, 25 V, radial
C_6 = 0.1 μF

Semiconductors:
D_1, D_7 = 1N4001
D_2 = LED, yellow, high efficiency
D_3, D_4 = 1N4148
D_5 = LED, red, high efficiency
D_6 = LED, green, high efficiency
T_1 = BC337

Integrated circuits:
IC_1 = 7805 (12 V) or 4805 (6 V)
IC_2 = TLC271CP

Miscellaneous:
K_1 = socket to suit mains adaptor
Re_1 = 12 V or 6 V relay (see text) with single change-over contact
Non-regulated mains adaptor, 12 V or 6 V output
PCB Order no. 970092 (see Readers Services towards end of this issue)

Figure 2. The printed-circuit board for the maintenance charger is available ready-made—see Readers Service section towards the end of this issue.

1:6 divider R_8–R_{10} ensures that this voltage is applied to the –ve (inverting) input of IC_2.

The reference voltage of 2.1–2.3 V is applied to the +ve (non-inverting) input of the IC. The reference voltage is derived from the 5 V line, which is regulated by IC_1, via potential divider R_2-R_3-P_1-D_3-D_4. Diodes D_3 and D_4 provide the requisite temperature compensation.

The hysteresis of the comparator is held at a fixed value of 0.2 V by R_4.

DISPLAY AND PROTECTION

The various modes of operation of the charger are indicated by three light-emitting diodes (LEDs).

A yellow one, D_2, is linked in parallel with K_1 via resistor R_1. It lights when the mains adaptor is connected and switched on. If the mains adaptor is not, or wrongly (almost impossible), connected, the diode does not light. In this case, diode D_1 short-circuits the output of the mains adaptor to prevent any damage to the charger. The short-circuit may well irreparably damage the adaptor, though.

It must also be said that when during charging the mains adaptor is switched off, D_2 continues to light since it is then supplied by the battery via the closed relay contact.

A red diode, D_5, is in series with the relay to indicate that the battery is being charged.

A green LED, D_6, in parallel with the battery, indicates whether or not this is connected correctly (polarity!). If the battery is connected with wrong polarity, not much can go awry, but, of course, it will not be charged. In the unlikely case that the relay contact closes just at the moment the battery is being connected with wrong polarity, the battery may be discharged via D_1. This will, however, be of short duration since the relay contact opens only briefly when there is no battery connected to the charger..

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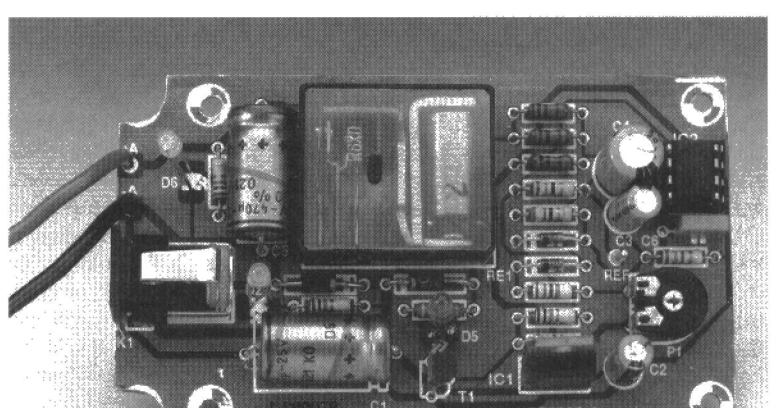

Figure 3. Photograph of the completed prototype board.

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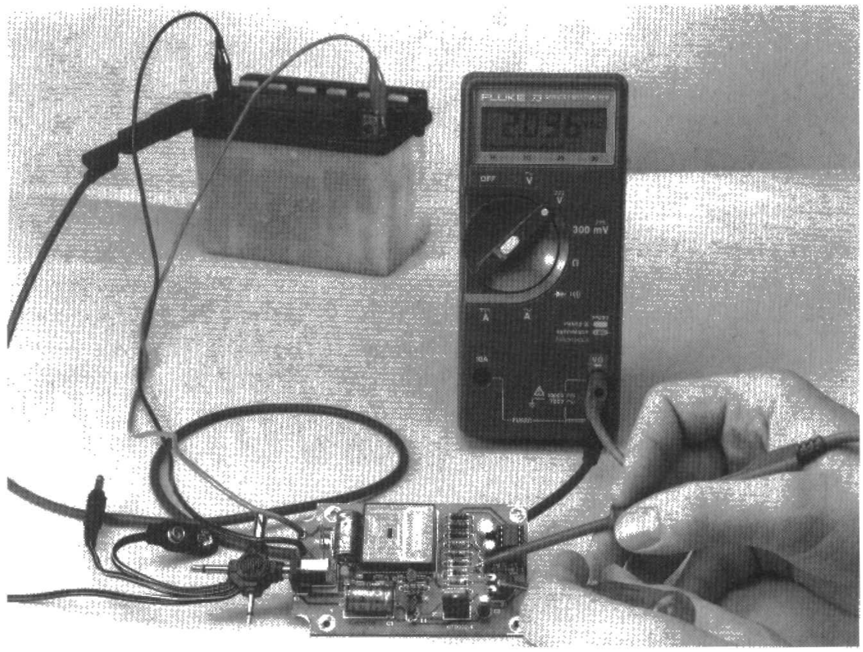


Figure 4. Photograph of a typical setup for setting the reference voltage. Note that although the battery is shown connected, it should not be when setting takes place.

USING THE CHARGER

When the battery is connected to the maintenance charger for the first time, check that D_6 lights before connecting and switching on the mains adaptor. If it does, all is well.

Note that the charger has no additional short-circuit protection. This means that when the battery terminals are accidentally short-circuited, or the mains adaptor is connected the wrong way around (which is virtually impossible), the only protection is the current limiting action in the adaptor. As already described, this is provided by just a few resistors, and these will not hold out for very long.

When the reference voltage is set to 2.1 V, charging commences when the potential at the –ve (inverting) input of IC_2 is 2.1 V and, owing to the in-built hysteresis, stops at 2.3 V. Referred to a 12 V battery, charging starts at a terminal voltage of 12.6 V and stops at 13.8 V. In practice, this arrangement ensures that the battery is charged briefly a couple of times per day.

It is, of course, possible to modify the reference voltage. If, for instance, this is set to 2.05 V, the intervals between charging periods are larger. However, these intervals should not be made too long to ensure that you have a fully charged battery available at all times.

If the battery does not appear to charge properly, badly sulphated plates may be indicated. The voltage across the battery then increases rapidly, whereupon charging ceases. In a bad case, charging will stop after only four seconds. If the sulphation is not too serious, the battery may recover to some extent, so that it is worthwhile to leave it connected to the maintenance charger for a day and then check the charging again. Sulphation of the plates cannot be reversed: the battery is then a write off and must be replaced.

CONSTRUCTION AND TEST

The maintenance charger is best built on the printed-circuit board shown in **Figure 2**. Completing the board is simplicity itself: provided the drawing is followed closely, nothing can go wrong, but mind the polarity of the various capacitors and diodes.

When the board is completed, connect the mains adaptor to K_1 and switch it on. Do not connect a battery to the charger. If all is well, the relay should close for one second, and then open again, and repeat this process every four seconds.

When all is found in order, the board should be housed in a suitable enclosure. The prototype is housed in a small metal case with holes drilled as appropriate for the LEDs, the socket for connecting the mains adaptor, and the terminals to which the battery is to be connected.

The battery is best linked to the charger via two lengths of flexible, well-insulated, not-too-thin multi-strand circuit wire. It is advisable to use red wire for linking the +ve terminals, and black for the –ve terminals.

Before taking the charger into use, connect a multimeter, set to the 10 V direct voltage range, between 'REF' and '–A' on the board. Connect the mains adaptor and switch it on. Do not connect a battery. The relay will then close and open at four-second intervals. Adjust P_1 for a meter reading of 2.1 V at the moment the red LED does not light. If this test is carried out at an ambient temperature other than 20 °C, reduce the meter by 4 mV for each °C the temperature is higher and increase it by the same amount for each °C it is lower.

6 V BATTERY

The charger described so far is intended for use with a12 V battery. It is, however, readily adapted for use with a 6 V battery as follows.

- Set the mains adaptor to 6 V output, or use a 6 V model.
- Replace IC_1 by a low-drop type, such as the 4805.
- Replace the relay by a 6 V type.
- Remove R_9 and replace R_8 by a 20 kΩ, 1% type.
- If D_2 and D_6 light too faintly, replace R_1 and R_{11} by 3.9 kΩ types.

[970092]

Basic cell reactions in lead-acid battery

The chemical reactions in a standard lead-acid battery are:

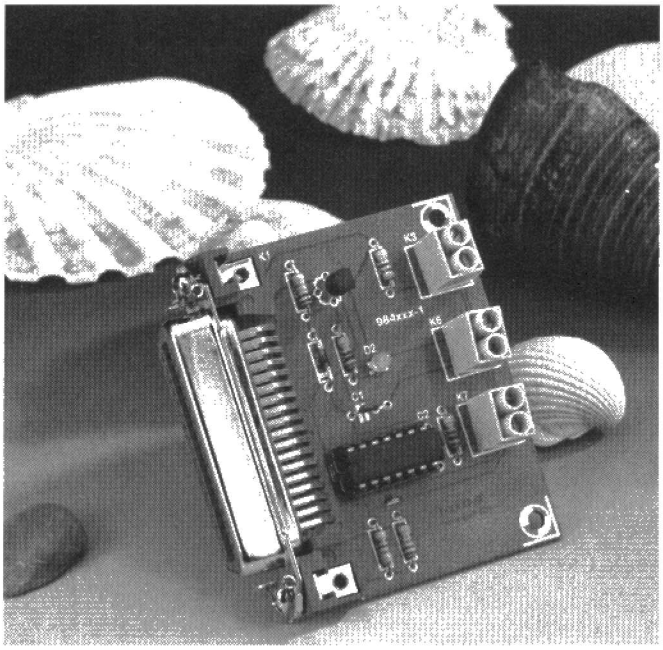
Discharge	$PbO_2+Pb+2H_2SO_4 \rightarrow 2PbSO_4+2H_2O$
at +ve electrode	$PbO_2+3H^++HSO_4+2e \rightarrow 2H_2O+PbSO_4$
at –ve electrode	$Pb+HSO_4 \rightarrow PbSO_4+H^++2e$
Charging	$2PbSO_4+2H_2O \rightarrow PbO_2+Pb+2H_2SO_4$
at +ve electrode	$2H_2O+PbSO_4 \rightarrow PbO_2+3H^++HSO_4+2e$
at –ve electrode	$PbSO_4+H^++2e \rightarrow Pb+HSO_4$

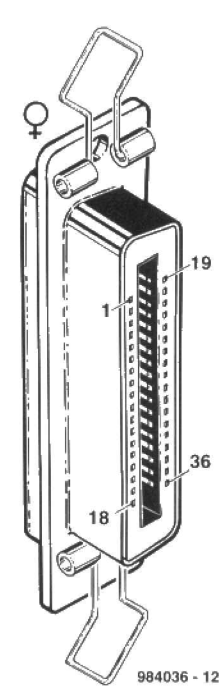
$PbSO_4$ = lead sulphate

024 PIC16C84 programmer for Centronics port

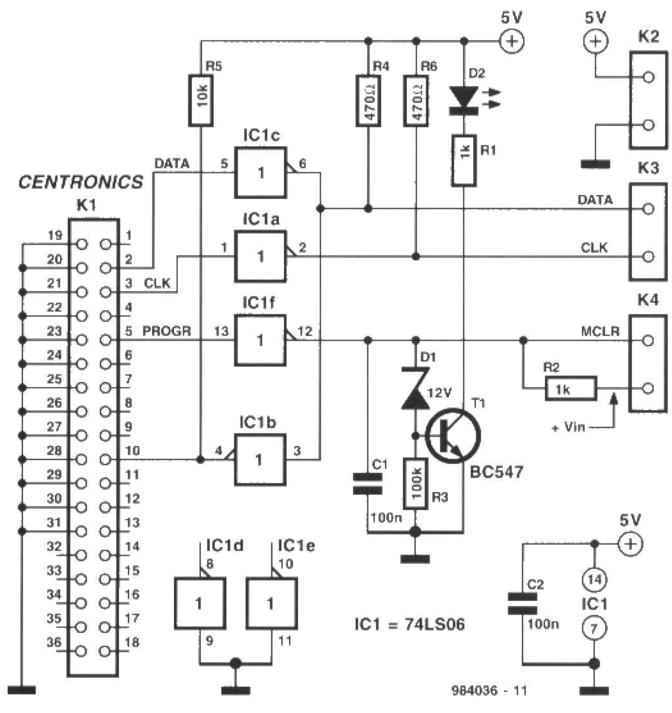
Design: R. Weber

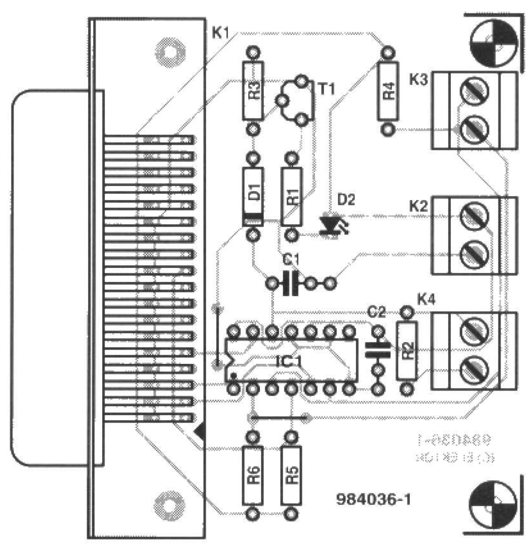
Among the most popular shareware programs for PIC16C84 programming is PIP02 from Silicon Studios. The circuit shown here also uses PIP02, but in combination with a special driver written by Dave Tait. This driver, DTAIT.EXE, allows PIP02 to communicate with PIC programmer hardware via the parallel printer ('Centronics') port. The hardware does not amount to much and is cheap, too — the PCB-mount Centronics connector is probably the most expensive part! A single 74LS06 (hex open-collector inverter) is used to enable the Centronics port and the PIC (to be programmed) to talk to each another. Three data lines of the Centronics port, D0, D1 and D3 are first inverted

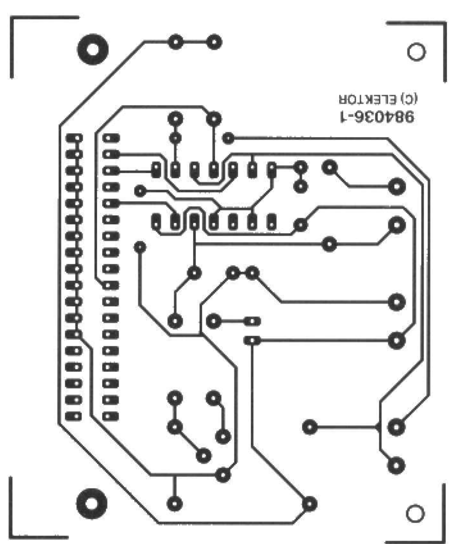




984036 - 12







COMPONENTS LIST

Resistors:
R1,R2 = 1kΩ
R3 = 100kΩ
R4,R6 = 470Ω
R5 = 10kΩ

Capacitors:
C1,C2 = 100nF

Semiconductors:
D1 = 12V 0.4W zener diode
D2 = LED
T1 = BC547
IC1 = 74LS06

Miscellaneous:
K1 = Centronics socket, PCB mount
K2,K3,K4 = two-way PCB terminal block, pitch 5mm
PCB, order code 984036-1

and then applied to the PIC to be programmed. D0 supplies data, D1 clock pulses, and D3 programming pulses. Information returned by the PIC to the PC is first inverted by gate IC1b and then applied to the BUSY line on the Centronics connector.

The PIC to be programmed is connected as follows:

K3 DATA to RB7 (pin 13)
K3 CLOCK to RB6 (pin 12)
K4 MCLR to $\overline{\text{MCLR}}$ (pin 4)
K2 +5V to VDD(pin 14)
K2 GROUND to VSS (pin 5)

The +Vin terminal of K4 is connected to an external 12-volt supply for the programming voltage. LED D2 lights when programming pulses are applied. Zener diode D1 protects the base of T1 against the programming voltage. The programmer needs two external supply voltages: 12 V (PIC programming voltage) and 5 V (74LS06 and the LED supply voltage).

The two programs you will need to use the programmer may be obtained free of charge from the Internet from this url: *http://www.sistudio.com/sistudio/download/html.*

`DTAIT.EXE` is unzipped from the 'PINAPI Drivers DOS Pack 1'. Having downloaded these programs, all you have to do is write the following batch file:

```
DTAIT.EXE 7406
PIP02.EXE
DTAIT.EXE REMOVE
```

and launch it from the DOS prompt. Finally, the printed circuit board shown here is available ready-made from the Publishers.

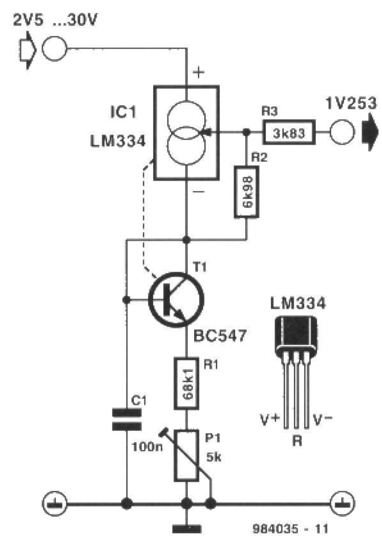
(984036-1: LL)

025 low-power voltage reference

The present reference is a special application of current source IC Type LM334. It has a tiny temperature coefficient and draws only a minute current: at room temperature, only 10 μA, which increases with large rises in temperature by only a few μA.

The circuit is basically a bandgap reference, because the positive temperature coefficient of the LM334 is combined with the negative temperature coefficient of the base-emitter junction of a transistor (which ensures good thermal coupling).

To obtain a temperature coefficient of zero, or very nearly so, the output voltage of the circuit is adjusted to exactly 1.253 V with P_1. It is, therefore, advisable to measure the set value of P_1 accurately after it has been adjusted and to replace the combination of R_1+P_1 by a fixed resistor of the precise value. Use a 1% metal-oxide film type from the E96 series.



Since current source IC_1 is tapped at the control input, a reference source with a negative output resistance of about 3.8 kΩ ensues. Resistor R_3 ensures that the ultimate output resistance is about 400 Ω. The load current is then limited to not more than 5 μA.

The performance of the reference is good: when the input voltage is increased from 5 V to 30 V, the output voltage varies by only 0.6 μV (from 1,2530 V to 1.2536 V).

The temperature coefficient stays below 50 ppm °C^{-1}, and, with careful adjustment, may even come down to 5 ppm °C^{-1}.

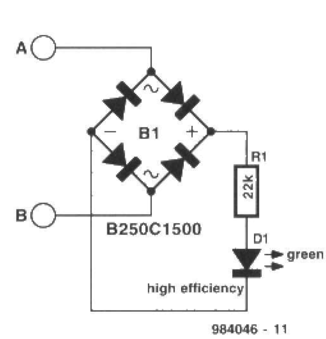
The current drawn by the prototype is 9.8 μA at an ambient temperature of 22 °C.

[Giesberts – 984035]

026 modem off indicator

Design: H. Bonekamp

The modem off indicator is intended especially for serious Internet surfers. It will be seen that the circuit of the indicator cannot be much simpler, or there might be nothing left. In spite of its simplicity, it may prove to be a cost-saving device, since it shows at a glance whether the telephone line is free again after the modem has been used. This obviates high telephone charges in case for some reason the modem continues to operate.



The circuit depends on the fact that there is a potential of about 40 V on the telephone line when it is not busy. This voltage drops sharply when a telephone call is being made. If, therefore, the circuit is linked to telephone terminals *a* and *b*, the lighting of

the green LED shows that the line is not busy in error.

The bridge rectifier ensures that the polarity of the line voltage is of no consequence. This has the additional benefit that polarity protection for the LED is not necessary.

To make sure that the telephone line is not loaded unnecessarily, the LED is a high efficiency type. This type lights at a current as low as 2 mA, and this is, therefore the current arranged through it by resistor R_1.

[984046]

WARNING. In spite of the liberal age we live in, it is highly probable that in many countries it is not allowed to connect the indicator across the telephone lines. Seek advice of your local telephone company that owns or operates the telephone network.

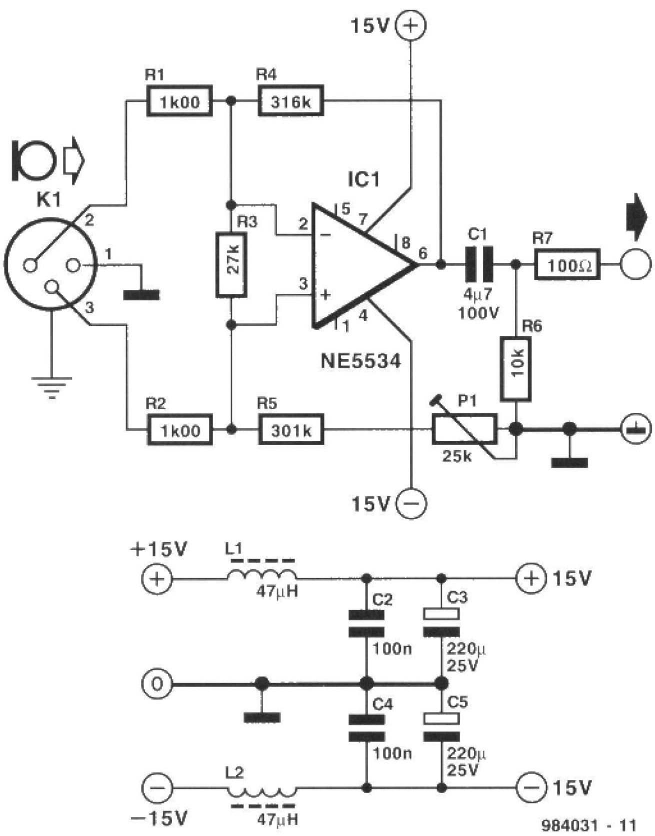
027 balanced microphone preamplifier

Design: T. Giesberts

The preamplifier is intended for use with dynamic (moving coil – MC) microphones with an impedance up to 200 Ω and balanced terminals. It is a fairly simple design, which may also be considered as a single stage instrument amplifier based on a Type NE5534 op amp.

To achieve maximum common-mode rejection (CMR) with a balanced signal, the division ratios of the dividers (R_1-R_4 and R_2-R_5 respectively) at the inputs of the op amp must be identical. Since this may be difficult to achieve in practice, a preset potentiometer, P_1, is connected in series with R_5. The preset enables the common-mode rejection to be set optimally.

Capacitor C_1 prevents any direct voltage at the input, while resistor R_7 ensures stability of the amplifier with capacitive loads. Resistor R_3 prevents the amplifier going into oscillation when the input is open circuit. If the microphone cable is of reasonable length, R_3 is not necessary, since the parasitic capacitance of the cable ensures stability of the amplifier. It should be noted, however, that R3 improves the CMR from >70 dB to >80 dB.



Performance of the preamplifier is very good. The THD+N (total harmonic distortion plus noise) is smaller than 0.1% with an input signal of 1 mV and a source impedance of 50 Ω.

Under the same conditions, the signal-to-noise ratio is –62.5 dBA.

With component values as specified, the gain of the amplifier is 50 dB (×316).

After careful adjustment of P_1 at 1 kHz, the CMR, without R_3, is 120 dB.

The supply voltage is ±15 V. The amplifier draws a current at that voltage of about 5.5 mA. Note the decoupling of the supply lines with L_1, L_2, C_2–C_5.

[984031]

028 oscillation monitor

Design: F. Hueber

The circuit in the diagram was originally designed to monitor an oscillator, but can also be used as a general-purpose level indicator for a.c. signals. It is based on a quadruple IC containing four NAND gates. Only three of the gates are used, making the fourth free for other purposes. All the gates have a Schmitt trigger input.

When a 5 V supply is used, the Type 74HC132 is recommended; for higher voltage, a Type 4093. Note, however, that these two ICs have different pinouts. In the diagram, the differing pins of a 4093 are shown in brackets.

The signal to be monitored is applied to the input of the first gate via capacitor C_1. Resistor R_2, in conjunction with the protection diode in the IC, guards the input to high voltages.

In the absence of a signal, resistor R_1 holds the input high so that the output of the gate is low.

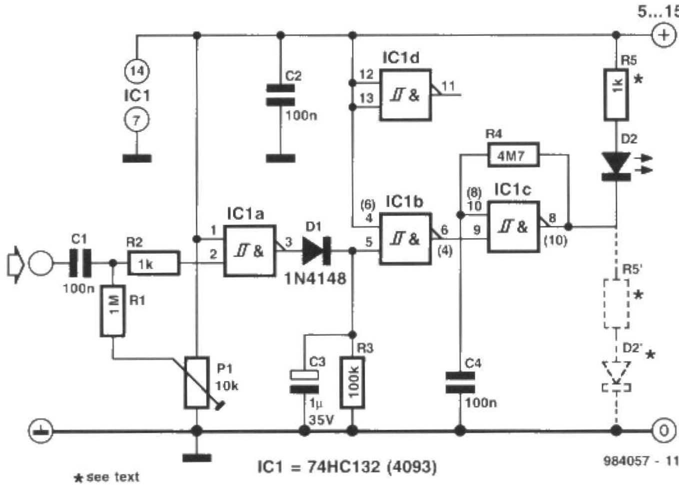
When a signal of sufficient strength is received, the input of the gate goes low during the negative half cycle of the signal, so that the output of the gate goes high in rhythm with the input signal. However, the Schmitt trigger converts sinusoidal signals into rectangular ones, which charge capacitor C_3 via diode D_1. When the potential across C_3 exceeds the threshold at the input of the second gate, this gate also toggles.

The output of the second gate is then low, which disables the third gate, which functions as an oscillator.

When the level of the input signal drops, C_3 is discharged via R_3. The potential across the capacitor then no longer exceeds the threshold at the input of IC_{1b}, whereupon IC_{1c} is enabled and the LED flashes

The LED may be connected as shown or as indicated by the dashed line. As shown, the diode remains off when there is an input signal of sufficient strength and begins to flash when the signal fails or its level drops. When the diode is linked to earth, it is on continuously when there is an input signal, and begins to flash when the input drops.

When a 5 V power supply is used, R_5 = 1 kΩ, and the circuit draws a current, including that of the LED, of 3 mA. The frequency of the input signal may lie between 10 Hz and 10 MHz.



When a 9–12 V supply is used, the value of R_5 must be altered as necessary. Owing to the 4093 being slower than the 74HC132, the upper frequency of the input signal is then limited to 3 MHz.

When the wiper of P_1 is at the level of the supply voltage, the response threshold, U_{SS}, lies between 3.5 V (when U_b = 5 V) and 7 V (when U_b = 12 V). When the wiper is moved away from the positive supply line, U_{SS} (max) is 1.5 V (when U_b = 5 V).

The response threshold is quite precise: a drop in the input signal level of 50–100 mV is sufficient to disable the input.

When the input level is too high, a preset across the input terminals enables the level to be reduced to a value that lies in the desired range above the response threshold. [984057]

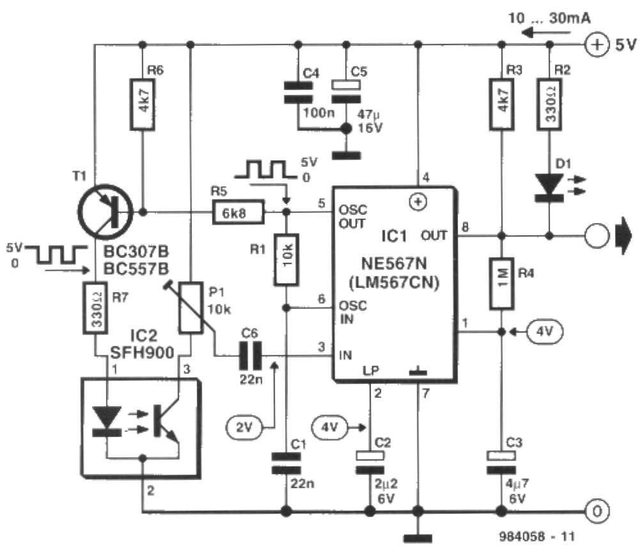
029 infra-red proximity detector

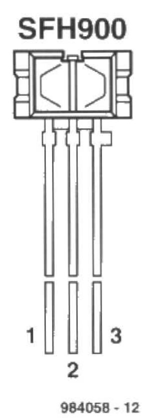
Design: K. Hagen

The detector is intended for the recognition of obstructions at distances of a few millimetres to a few centimetres. Similar detectors are used in the industry and health services, for instance, to open a water tap via a magnetic valve.

The sensor, IC_2, is a Type SFH900 optoisolator from Siemens or similar. A phase-locked loop (PLL) in decoder IC_1 compares the frequency of the input signal from IC_2 with that of an internally generated signal. When the two signals fall within the same band, the output, pin 8, of IC_1 changes state (from high to low).

The internal oscillator generates a signal at a frequency of about 4.5 kHz (determined by time constant R_1-C_1. Its rectangular signal at pin 5 switches on the light-emitting diode in IC_2 via T_1. The diode then transmits an infra-red light signal pulsed at 4.5 kHz.





When the infra-red light is reflected by a nearby object, the photo transistor in IC_2 provides a signal to pin 3 of IC_1 If the frequency of this signal lies within the same band as that of the internal generator, pin 8 is connected to earth, whereupon diode D_1 lights. The comparison by the PLL prevents the circuit reacting to stray light.

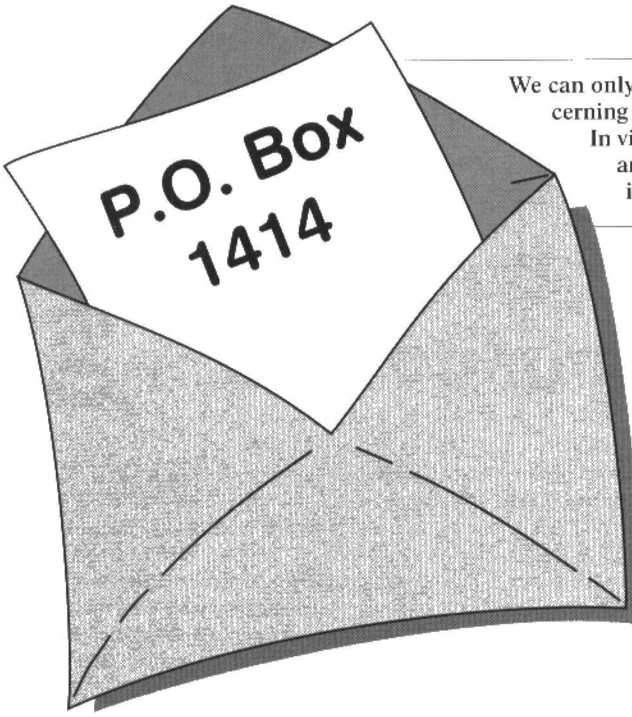
The sensitivity of the detector may be varied with P_1.

The detector with components as specified draws a current of 10–30 mA.

As stated earlier, the optoisolator may be one of several types. It may also be built from a discrete LED and phototransistor, but great care should then be taken to ensure that the photo transistor cannot receive light transmitted by the LED.

A suitable solid-state relay at the output enables larger loads to be switched. Circuit IC_1 can switch currents of up to 100 mA to earth. Diode D_1 should then be omitted.

[984058]



We can only answer questions or remarks of general interest to our readers, concerning projects not older than two years and published in *Elektor Electronics*. In view of the amount of post received, it is not possible to answer all letters, and we are unable to respond to individual wishes and requests for modifications to, or additional information about, *Elektor Electronics* projects.

Video Copy Processor

Dear Editor — having read your excellent magazine for a number of years, I've occasionally attempted the odd project. My latest venture was the Video Copy Processor of November 1997. Having assembled the components and soldered them in position with the diligence of a brain surgeon, lo and behold it worked perfectly first time around (rare for me). While demonstrating it (not without a certain amount of panache) to my son, he informed me (not without a certain amount of schadenfreude) that he had been copying (legally I hope) for years using his modern VCR and my old (discarded) top-loader to record with, with very watchable results. Maybe some of your buffs could enlighten me as to this phenomenon. Meanwhile anyone want to buy a little used Video Copy Processor? Kids, who'd have them!

M. Fitzgerald, Limerick

Many thanks for your letter, and congratulations on successfully building this project.
As we already explained in the earlier (1988) article on Macrovision, many older VCRs are not bothered at all by copy protection signals, so again it seems wise not to bin 'obsolete technology'. Briefly, the 'phenomenon' you have witnessed is caused by the sync-flywheel circuit available in your son's old top-loader VCR. The flywheel circuit was originally intended to overcome picture instability as a result of tape speed variation and other tracking irregularities. Modern VCRs have much better tape speed control, use better tapes, and hence do not need the old flywheel system. However, as you have seen, it is still very useful!

EPROM Programmer

Dear Editor — I have just built the EPROM Programmer featured in your March 1997 issue, and want to inform you about a problem I encountered. I made my own PCB for this project and used locally obtained parts.
During the first test I got the message "wrong hardware". Selecting ECP, EPP or indeed any other printer port mode made no difference. I examined the operation of the board step-by-step using BASIC but could not find any error in the hardware. Using BASIC I was able to manually control the parallel port register.
These tests took a lot of time. Finally, when I had the register bits set in the right order, I was ready to go from BASIC directly to Windows. I did not believe my eyes, the board worked.
I have now solved the problem using this very small BASIC program:

```
'Set LPT1
'in bidirectional mode
OUT &H378 + &H402, 32 + 21
OUT &H378, 32
```

When I run this program before PROMMER.EXE, the EPROM programmer works as expected. For your records, the motherboard in my computer is a Pentium P51430VX-250 Explorer. What is the actual source of the problem I have stumbled on? Is it poor standards for the parallel ports, or a deficiency in your software?

Sved Martinsson (by email)

On this (extremely popular) project we received a number of enquiries similar to yours. As far as we have been able to discover, the problem may be caused by non-standard initialisation of the EPP port mode at the BIOS level. None of our prototypes gave evidence of this, however, and obviously it's just not possible to test the project using each and every PC motherboard available on the market! We are grateful for being able to print your BASIC program because it may helpful to other readers experiencing communication problems with the EPROM programmer.
(See also 'Unidirectional Version of EPROM Programmer', Elektor Electronics September 1997, p. 72)

Software

I have been wondering for some time now why it is not possible for subscribers to your magazine to automatically receive the software with published designs. I refer to software for stand-alone programs as well as for controllers. This occurred to me because although you publish designs for programmers, it is not possible to use the very same designs for subsequent projects based on microcontrollers, which, alas, I can only obtain ready-programmed through your valued Readers Services, or a kit supplier.
I was thinking along the lines of a 'extra-value' subscription, slightly dearer than the normal subscription but with the publishers automatically supplying the requisite software. Of course, this could be implemented using the Internet. 'Extra-value' subscribers would then receive a key (digital code) allowing them to once download the software from an Internet site.
I hope you will at least consider my suggestion.

G. Bouland

Thanks for your constructive criticisms. To us, software development is a very time-consuming activity and therefore often left to free-lance contributing authors, who negotiate and receive remuneration for each copy sold. Unfortunately this remuneration system is hard to implement in your 'extra-value' subscription scheme, although offering or selling software via the Internet is, we feel, a viable option. Unfortunately, existing payment systems are not (yet) attractive when it comes to selling relatively low-priced products in this way.
For some time now we have been busy resolving the problem of unobtainable source code files. These will be made available in those cases where (1) it makes sense to make source code files available to

our readers, and (2) the author has transferred the relevant file(s) and copyrights to us.

Monacor/Monarch Parts

Dear Editor — a fair number of recently published articles are based on components supplied by a company called Monacor/Monarch (or even Mercator). To date I have been unable to locate their representative in the UK and, indeed, any of the Monacor parts you specify. Where can I obtain these parts (mostly connectors, transformers and moving-coil meters)?

F. Anderson, Ipswich

By most standards, Monacor is a large supplier of electronic parts with distributors in nearly all European countries. Until recently, the parent company, the German Inter-Mercador GmbH, did not have an outlet in the UK. Fortunately, Monacor UK (Ltd) are now in business and can be reached on the following numbers: tel. (01908) 217100, fax (01908) 217900. We should also mention that most Monacor components we refer to can be supplied as one-offs by two of our advertisers, Stippler Electronics and C-I Electronics, mainly because they also carry kits for many of the projects featured in Elektor Electronics.

Elektor Item Tracer

Dear Editor — I recently ordered and received the Elektor Item Tracer (EIT). However I have not been able to run the program despite the fact that all files are present according to your checking program.
I get the message 'Cannot find MSAJT200.DLL' when I try to run the program, and then the installation program terminates.
I remember seeing something about this in a past issue but can not now locate the relevant issue. Please tell me how to get the missing file, preferably through the Internet.

Michail Kalognomos, by email

This problem is simple to solve. Locate the file MSAJT110.DLL on your system, and rename it to MSAJT200.DLL. The EIT installer should then work properly.
A few other readers have reported that the EIT will not launch after an otherwise successful installation. An error report 'File not found' then appears. Because this is a rare problem, we have been unable so far to discover the exact cause. A makeshift solution is to rename the file MSAJT110.DLL into MSAJT112.DLL before running the EIT installer.

Charging NiMH Batteries

Dear Editor — I have a query on charging the new NiMH penlight batteries from Philips. On the label it says that these batteries can be used in any charger. With a suspicious mind I called the Philips Consumer Information Desk, only to be told that there was no danger of the batteries being damaged by over-charging.
My actual questions to you are: I have a charger supplying a current of 50 mA. The NiMH batteries have a capacity of 1100 mAh. How long should I leave them in the charger? I also have another charger with 130 mA output capacity. How long should I leave it on to recharge my NiMH batteries?
My questions may appear very simple, but I am fully aware of the fact that the total amount of energy needed to charge the batteries is greater than the energy I can drain from them. I would also like to fully charge the batteries without any risk of over-charging.

S. van Rhijn, Netherlands

One of the major differences between NiCd and NiMH batteries is that the latter are slightly less robust and less tolerant of high charging and discharging currents. The latter fact is important for fast charging only.
One of the rules of thumb that also applies to NiMH batteries is that the charging current is 1.4 to 1.5 times the specified capacity. So, your 1100 mAh batteries will require a total charge of 1500 to 1650 mAh. In other words, you should charge them for 12 hours at 130 mA, or for 32 hours at 50 mA.
For safe charging a charging period of 14 to 15 hours is commonly applied, using a current equal to 1/10th of the battery capacity. So, your 130-mAh charger is almost the perfect companion for these batteries. The one advantage of the 50-mAh charger is that it allows the batteries to given a much longer charge without any danger. Even continuous charging should be without risk at this low current.

Electronic Code Lock

Dear Editor — I wish to bring to your attention that the output NAND gate of the Electronic Code Lock (September 1997) suffers to a small extent from contact bounce. I was able to prove this by adding a JK flip-flop set to 'toggle' state to the output. Ideally, this flip-flop should toggle at every pulse from IC2d. Unfortunately, the application of a NAND gate with Schmitt trigger inputs is no guarantee for complete elimination of pulses resulting from contact bounce. I was able to cure this problem by connecting a 1-μF electrolytic capacitor between pin 12 of IC2d and ground. In this way, the input remains logic low sufficiently long (approx. 1 s), and bounce pulses generated when S4 is released do not reach the output any more.

C. Tribolet

Contact bounce pulses are notorious troublemakers in digital circuits. For the problems you report with the Electronic Code Lock, the addition of a 1-μF cap is a possible solution.

Submitting Articles for Publication

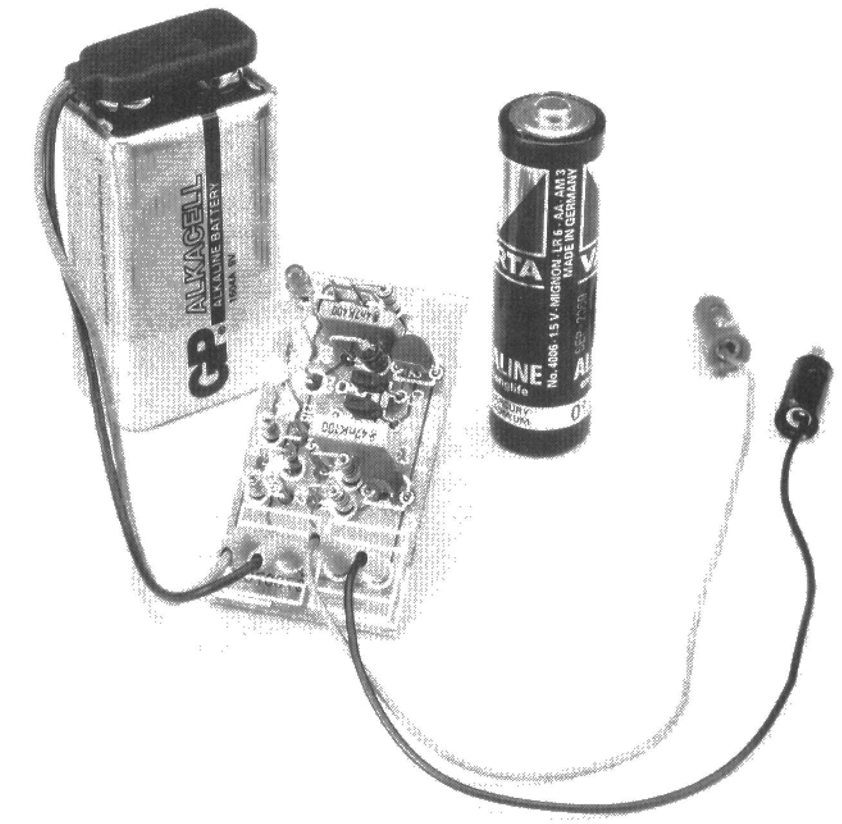
Dear Editor — I have developed a small project which I would like to offer you for publication. However, looking at the high quality of your articles I fear that what I have wrought on my kitchen table is just not good enough because of my limited skills at technical writing and my inability to design a high-quality printed circuit. Since I do not find a "Call for Designs" or similar section in your magazine, how does one actually go about submitting an article for publication in *Elektor Electronics*?

Well it's much simpler than you would expect, and there's no need to have reservations about low design standards because we will do the touching up if your article is accepted for publication.
Content is far more important than looks. Basically, your circuit has to be original and innovative, and other readers should be able to reproduce it as well as grasp its theory of operation. Once your design has been accepted for publication, you will receive a remuneration proposal from the Publisher, via our editorial secretariat.
Contrary to what you seem to think, we do not mind the odd spelling mistake or slip of the pen in your writs because most articles are virtually rewritten by our editorial staff in close co-operation with one of our internal design engineers appointed to oversee your project technically. So, there's absolutely no need to submit any 'mil-spec' documents!
What we do need, however, is a clear circuit diagram, short descriptions of the circuit operation and software (if used), and sources for all components used.
Although not strictly required, article proposals should be supplied on disk, using any of the popular file formats for word processing and PCB design. Why not give it a try?

Battery tester

for all 1.5V and 9V batteries

This battery tester does the job properly by evaluating the battery state under loaded conditions. The project is easy to build and contains regular components only. The battery read-out is a solid-state LED display rather than an expensive and fragile moving-coil meter. A special design feature enables the tester to make voltages below 1 volt light an LED.



Sure, there must be properly working testers around, but the ones we picked up and examined were not up to much. Okay, the designs may be simple (so is ours presented here), but most off-the-shelf testers are so poorly dimensioned that their battery condition indications are of little or no use. Some testers already indicate that the battery is okay if the thing produces any voltage at all, while others do not produce a 'good' verdict until a voltage of 2 V is measured; a cell voltage no dry battery will ever be able to produce!

So what are the 'must have' features of a good battery tester? Well, things are simpler than you might expect. Firstly, the voltage measurement should take place when a certain load is connected to the battery. That's because the no-load cell voltage does not tell us everything about the state of a battery. So, during the measurement a certain current must be drawn from the battery. Not a lot, mind you, but not so little either that no response is seen to the load.

The second important aspect to observe is to set up realistic values for the reference levels used during the voltage measurements. The present design is based on three test levels: 1.3 V, 1 V and 0.7 V. A measured voltage of 1.3 V or higher indicates a 'good' cell condition; between 1.3 and 1 V indicates 'acceptable'; below 1 V indicates 'poor', and below 0.7 V indicates 'flat'.

Two transistors and three LEDs

A look at **Figure 1** will convince you that the circuit diagram of the battery tester is pleasantly simple. Well, it could have been even simpler had we used the traditional moving-coil meter for the read-out. Because of the vulnerability and cost of such a mechanical meter, we decided to replace it by a totally electronic alternative: an array of LEDs with different colours. However, to make an LED light, you need a voltage between 1.6 V and 2.4 V. A bit of a problem, obviously, if you use a 1.5-V battery as the power source!

The problem was solved by calling in the help of an astable multivibrator (AMV). Here, the AMV is built around T1 and T2, and converts the 1.5-V battery voltage connected to K1 into an alternating voltage with a level of more than 5 V_{pp} which is developed across choke L1. The output frequency of the AMV is about 11 kHz.

The voltage across L1 is ample for our application because a usable tester may, in principle, be built by shunting the choke with an LED and a properly dimensioned series resistor. As you can see from the circuit diagram, two LEDs are connected in parallel with L1. Series resistor R4 belongs with the red LED, D1. Its value is such that the LED lights when the input voltage is just over 1 V. The green LED, D2, has a zener

Design by W. Zeiller

1

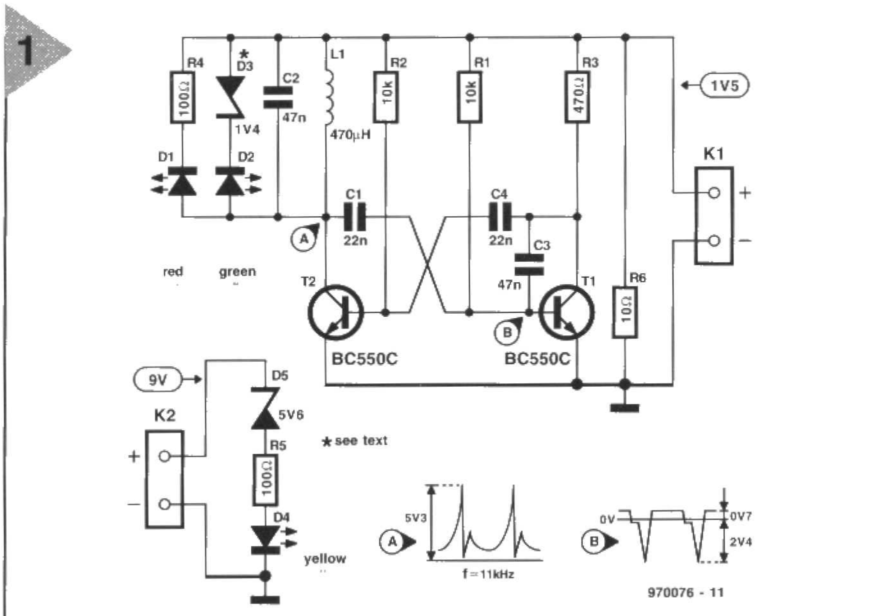


Figure 1. The circuit diagram of the battery tester is simplicity itself. Any 1.5-V dry cell may be connected to K1, while K2 is used for PP3 style 9-V batteries.

diode instead of a resistor. The diode enables the LED to light at a battery voltage of 1.3 V or higher.

Although the tester draws a current of about 30 mA , it is a too light load for battery test purposes. That's why resistor R6 is connected in parallel with the battery terminals. The value of 10 Ω indicated in the circuit diagram should be looked upon as a useful average for the most commonly used battery types. If you only test 'lady' or 'penlight' cells, then the load current may be made a little smaller, and R6 may be increased somewhat to, say, 15 Ω. For 'baby' and 'mono' cells, on the other hand, it may be better to adopt a slightly higher load current, and you may consider dropping the value of R6 to 6.8 Ω or so. Purists may, of course, fit a load switch to select between the two resistor values.

IN PRACTICE

Actually using the circuit is straightforward. Use two short, flexible wires to connect the 1.5-V battery you wish to examine to connector K1 on the board. Watch the polarity! LEDs D1 and D2 then indicate the state of the battery. A battery is only deemed 'good' if the green LED lights at reasonable intensity. A more detailed explanation of the LED indication may be found in the table.

To make the tester as versatile as possible, a test option for 9-volt (PP3) batteries has been added. These batteries may be connected to K2, and the test circuit consists of no more than a yellow LED (D4) with a zener diode (D5) and a resistor (R5) in series. The relevant component values enable the LED to light if the battery voltage is greater than 7.5 V.

The size of the printed circuit board for the battery tester (**Figure 2**) is smaller than that of a matchbox. Construction should take less than half an hour. The only point to pay attention to is the polarity of the LEDs and the zener diodes, in particular, D3. In general, zener diodes for low voltages are actually stabistors, or series-connected zener diodes. As compared with 'real' zener diodes, stabistors are fitted 'the wrong way around' on the printed circuit board. Don't worry, you can't damage the circuit if you fit D3 the wrong way around: only D2 will then refuse to light.

Our final remark also concerns D3. Because of the rather loose tolerance on the forward voltage of green LEDs, slightly better results may be obtained by using the next higher or lower value for the zener diode.

(970076-1)

2

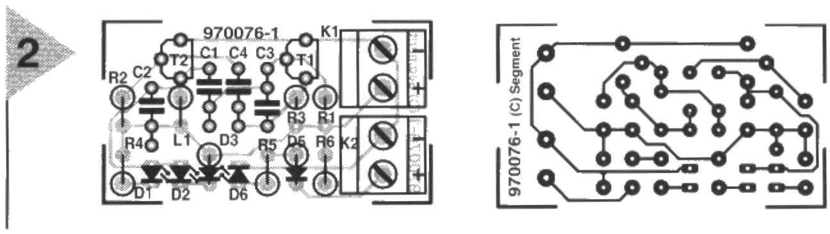


Figure 2. A circuit like this lends itself very well to miniaturisation (board not available ready-made).

readout

	D1 red	D2 green	1.5-V battery
> 1V3	●	●	both bright: good
	●	◐	weak green: reasonable
1V	◐	○	red only: poor
< 0V7	○	○	no red: flat

	D4 yellow	9-V battery
> 7V5	●	bright yellow: good
< 7V5	○	no yellow: bad

970076 - 13

COMPONENTS LIST

Resistors:
R1,R2 = 10kΩ
R3 = 470Ω
R4,R5 = 100Ω
R6 = 10Ω 1W

Capacitors:
C1,C4 = 22nF
C2 = 4nF7
C3 = 47nF

Inductor:
L1 470μH choke

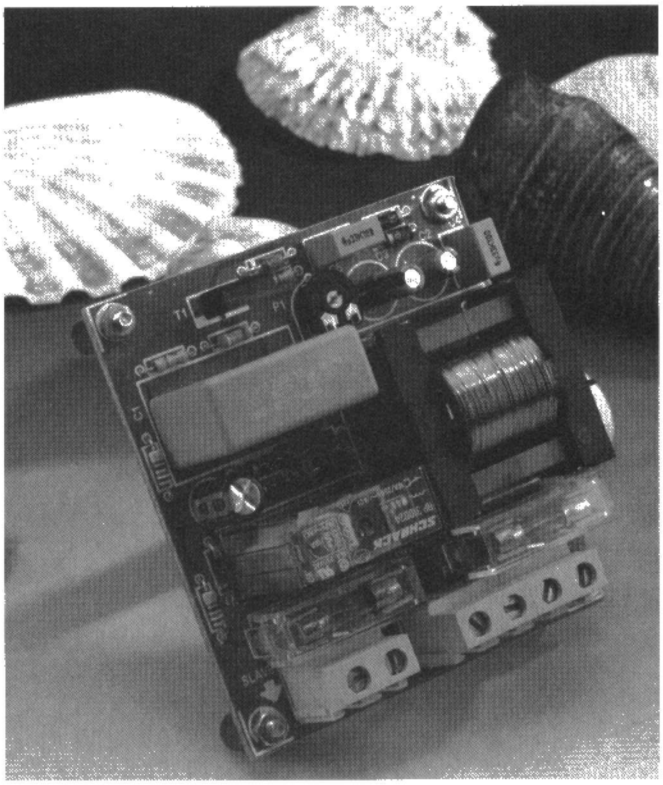
Semiconductors:
D1 = low-current LED, red
D2 = low-current LED, green
D3 = 1.4V zener diode, 0.4W
D4 = low-current LED, amber (yellow)
D5 = 5.6V zener diode, 0.4W
T1,T2 = BC550C

Miscellaneous:
K1,K2 = PCB terminal block, pitch 5mm

030

mains master/slave control Mk2

This circuit allows one or several mains-operated apparatus ('slaves') to be automatically switched on when a 'master' apparatus is switched on. It is basically an enhanced version of the 'Thrifty Mains-Slave Unit' published in the December 1996 issue of *Elektor Electronics*. This time, the design is complete with a PCB. Also, use is made of a current transformer made from wire with a diameter of 1.5 mm. The important consequence of this change is that higher master currents are allowed. In principle, up to 10 A is possible, but the terminal block connectors on the printed circuit boards are only specified at 5 A, so that's the highest current the master device is allowed to consume from the mains. Consequently, 5-A fuses are inserted in the 'master' and 'slave' supply lines, so that up to 1 kW of power may be switched in each of these 'channels' (assuming a mains voltage of 220-240 V, 50 Hz). Depending on your application, however, you may want to fit smaller fuses.

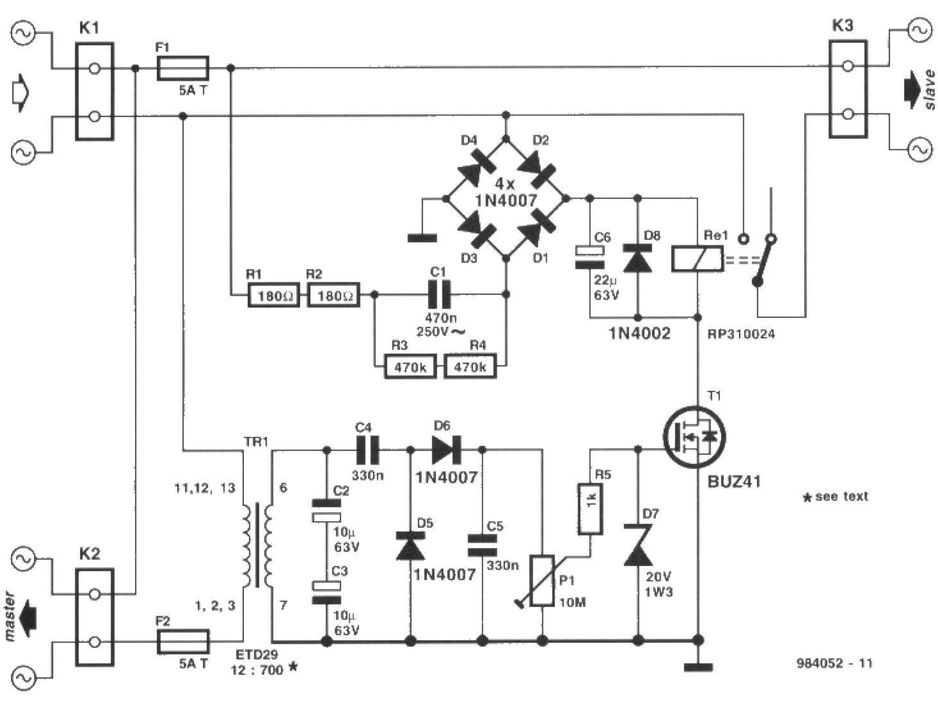


Transformer Tr1 is home made. The primary winding which carries the 'master' current consists of 12 turns (1 layer) of 1.5-mm (approx. 16 SWG) lacquered copper wire (CuL) on a type ETD29 core. The secondary winding consists of 700 turns of 0.2-mm (36 SWG) diameter CuL wire. You have to work carefully on the secondary winding if it is to fit in its entirety on the core. If you make a mess of it, the secondary winding will touch the core material. The primary and secondary windings should be isolated from each other using a tape layer or similar. Each of the wire ends of the primary is connected to three terminals of the core base. The primary winding drops less than 90 mV at a 'master' power consumption of 100 watts.

The 12:700 turns ratio used on the transformer ensures a maximum sensitivity of about 42 mA, or just over 10 watts of 'master' power consumption. If the 'slave(s)' need to be switched on at a higher 'master' wattage, then preset P1 may be adjusted accordingly

Resistors R1 and R2 limit the relay current to less than 1 A (peak), and capacitor C1 should be a type rated for operation at mains voltages. Note the use of two series-connected resistors in positions R1-R2 and R3-R4. Neither of these combinations should be replaced by a single resistor with the equivalent value because its maximum voltage rating is then easily be exceeded.

The target value for the relay voltage is about 28 V. This is determined by the mains voltage in combination with the value of C1. For 220-V mains, use C1 = 0.47 μF, for 230-V/240-V mains, use C1 = 0.33 μF. Although the relay shunt capacitor, C6,



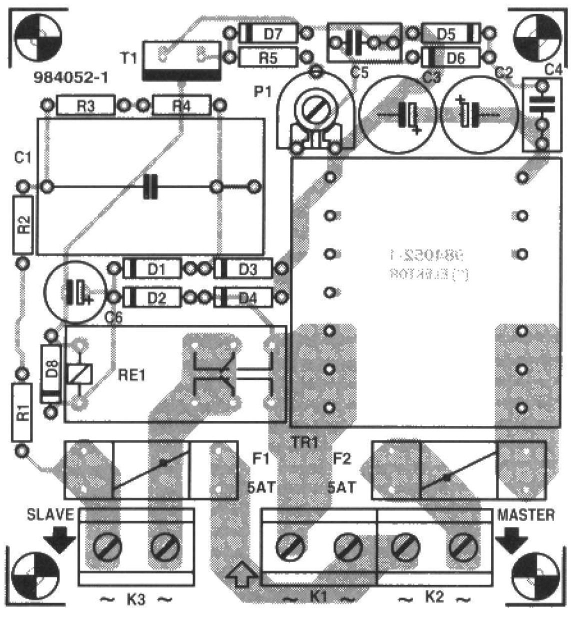
COMPONENTS LIST

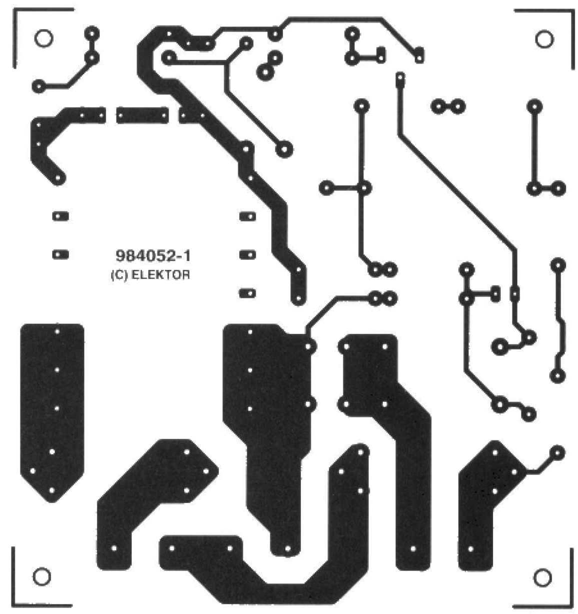
Resistors:
R1,R2 = 180Ω
R3,R4 = 470kΩ
R5 = 1kΩ
P1 = 10MΩ preset, H

Capacitors:
C1 = for 220-V mains: 470nF 250VAC class X2. For 230/240-V mains: 330nF 250VAC Class X2.
C2,C3 = 10μF 63V radial
C4,C5 = 330nF
C6 = 22μF 63V radial

Semiconductors:
D1-D6 = 1N4007
D7 = zener diode 20V 1.3W
D8 = 1N4002
T1 = BUZ41A (Siemens)

Miscellaneous:
K1,K2,K3 = 2-way PCB terminal block, pitch 7.5mm
F1,F2 = fuse, 5A slow, with PCB mount holder
Re1 = RP310024, 24V, 250VAC/16A (Schrack/Siemens)
Tr1 = ETD29 core (Philips). Primary: 12 turns 1.5mm dia. Cul wire. Secondary: 700 turns 0.2mm dia. CuL wire.
Printed circuit board, order code 984052-1.





'wastes' about 6 watts of mains power, it is smaller and cheaper than a 1.5-VA mains transformer!

Apart from adjusting the sensitivity, P1 also determines (to some extent) the time the 'slave' remains on after the 'master' has been switched off. Normally this delay will be about 3 seconds. For reliable operation of the relay, the U_{GS} potential of T1 should be greater than about 4 V. The mains master/slave control draws less than 27 mA with the relay switched on.

WARNING. Great care should be taken when working with this circuit since it is connected directly to the mains.

(984052-1)

031 LED bar off indicator

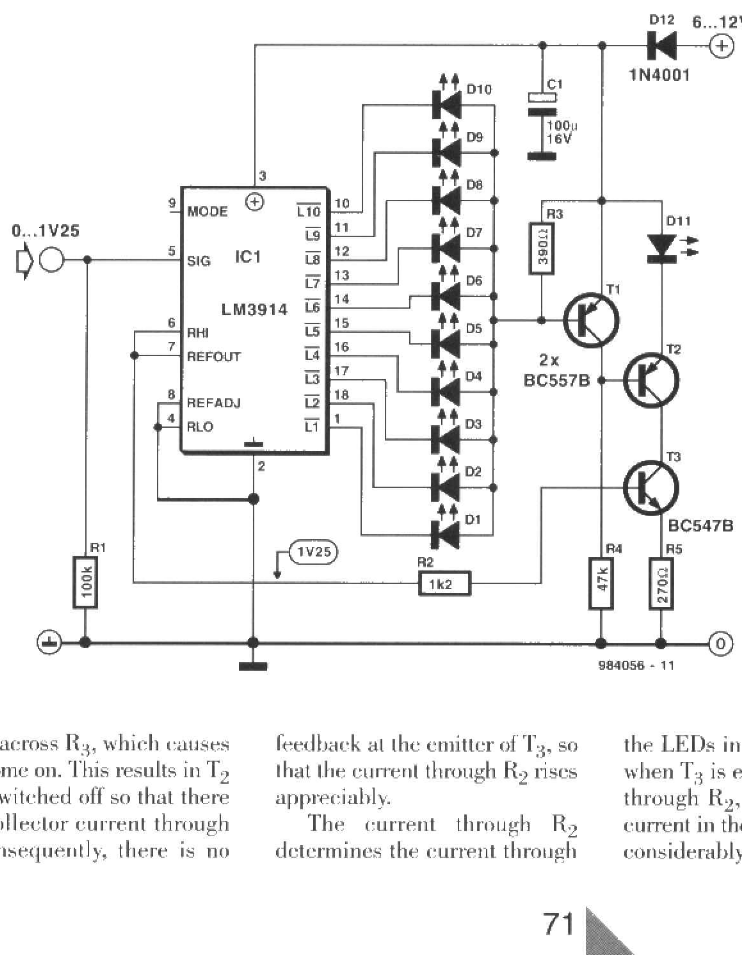
Design: H. Bonekamp

The simple indicator presented in this article may be combined, in principle, with any circuit that contains an LED bar display driven by a Type LM3914 IC. It ensures that an LED will light when all LEDs driven by the LM3914 are out. This prevents one drawing the erroneous conclusion that, since all the LEDs are out, the circuit is switched off. The circuit then continues to draw current, which, especially if it is battery powered, costs unnecessary money, apart from other considerations.

The LED in the monitor draws a current of only 1 mA.

When the LEDs forming the bar, D_1–D_{10} are all out, there is no potential difference across R_3, so that T_1 is off and T_2 is on. This results in T_3, in conjunction with R_5 and the internal reference voltage of IC_1, to form a current source that causes a constant current to flow through D_{11} so that the diode lights.

When on of diodes D_1–D_{10} lights, a potential difference ensues across R_3, which causes T_1 to come on. This results in T_2 being switched off so that there is no collector current through T_3. Consequently, there is no feedback at the emitter of T_3, so that the current through R_2 rises appreciably.

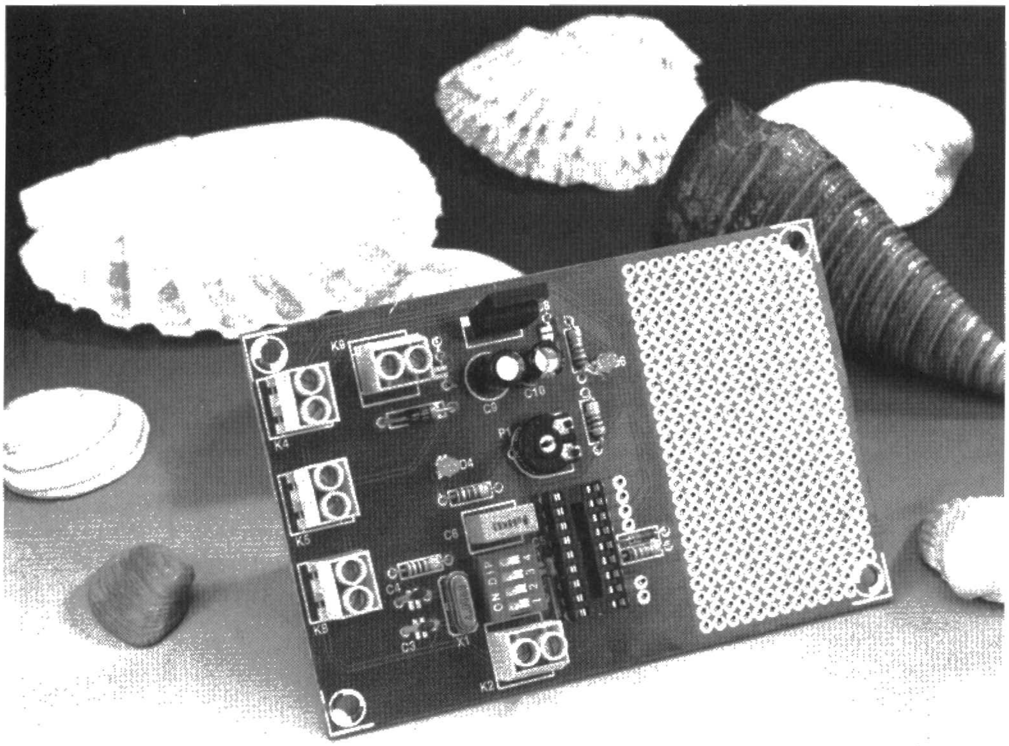


The current through R_2 determines the current through the LEDs in the bar. Therefore, when T_3 is enabled, the current through R_2, and thus the total current in the circuit, is reduced considerably.

[984056]

032

low-cost development system for PICs



Design: R. Weber

There can be no doubt that Microchip's PIC microcontrollers have achieved general acceptance in the electronics industry and immense popularity among hobbyists. Here, a PIC development system is presented that will not break the bank. The system should allow you to test the hardware operation of a PIC you have managed to program yourself. For such a test it is often necessary to connect simple input/output devices like LEDs and switches to various PIC port lines. Well, that is perfectly possible using the prototyping area on the board used to build this project. Provision is also made to connect either an external clock, a quartz-controlled clock or an adjustable RC controlled clock to the PIC. The first option is particularly useful if you want to slow down program execution to a speed at which it becomes possible to verify the operation of individual instructions.

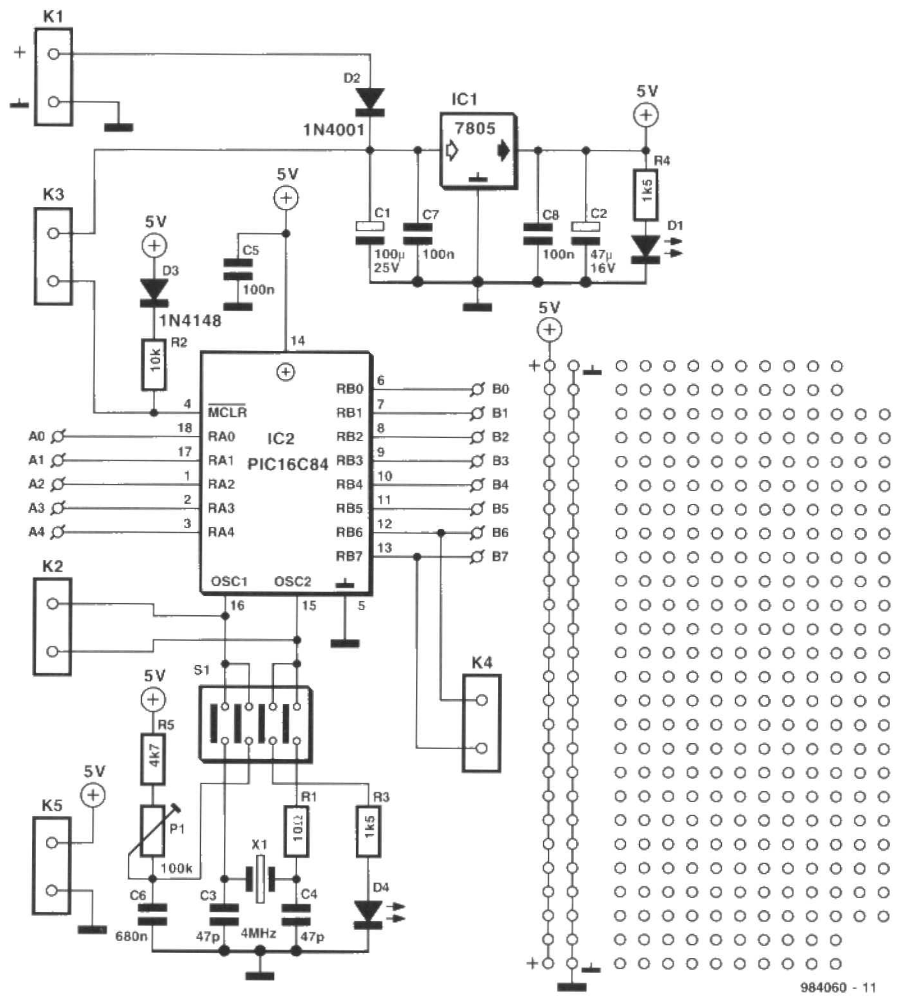
The development system has an on-board 5-volt supply based on the fully domesticated 7805 regulator. The (unregulated) input voltage (connected to K1) should not exceed about 12 V, and the regulator may have to be fitted with a heatsink depending on the current drawn by devices connected up to K5 and any LED indicators etc. on the prototyping area.

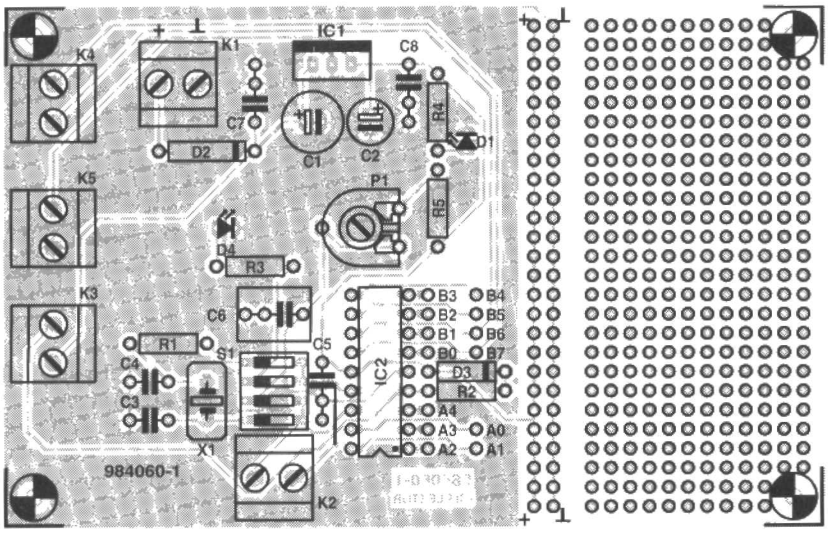
DIP switch block S1 serves to select one of the PIC clock sources mentioned above. If so required, an external clock signal is connected to K2. LED D4 serves to visualise the activity of a very slow clock (single-stepping!).

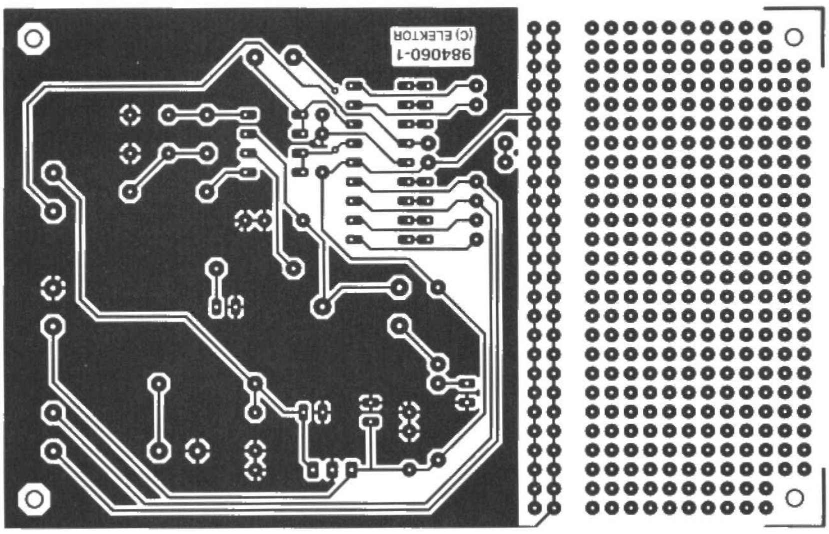
Using the solder spots around the PIC any one or all of the port lines may be wired to the prototyping area for connection to LEDs, switches, etc. used to simulate input/output devices.

Connectors K3 and K4 are intended for other projects developed by the author. Connector K5, finally, makes the on-board 5-volt supply voltage available to external devices.

(984060-1, LL)







COMPONENTS LIST

Resistors:
R1 = 10Ω
R2 = 10kΩ
R3,R4 = 1kΩ5
R5 = 4kΩ7
P1 = 100kΩ preset H

Capacitors:
C1 = 100μF 25V radial
C2 = 47μF 16V radial
C3,C4 = 47pF ceramic
C5,C7,C8 = 100nF
C6 = 680nF

Semiconductors:
D1,D4 = low-current LED
D2 = 1N4001
D3 = 1N4148
IC1 = 7805
IC2 = PIC16C84

Miscellaneous:
S1 = 4-way DIP switch
K1-K5 = 2-way PCB terminal block, pitch 5mm
X1 = 4MHz quartz crystal
Printed circuit board, order code 984060-1

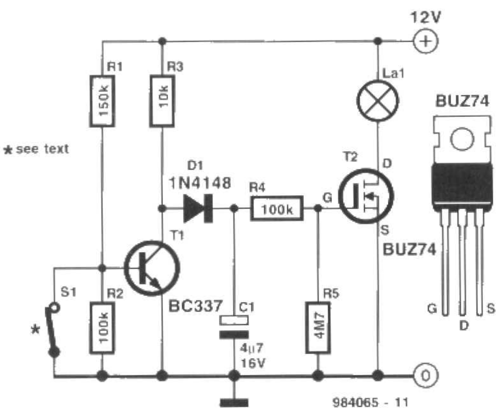
033 car interior lights delay

Design: W. Labudda

Most cars do not have delayed interior lights. The circuit presented can put this right. It switches the interior lights of a car on and off gradually. This makes it a lot easier, for instance, to find the ignition keyhole when the lights have gone off after the car door has been closed.

Since the circuit must be operated by the door switch, a slight intervention in the wiring of this switch is unavoidable.

When the car door is opened, the door switch closes the lights circuit to earth. When the door is closed (and the switch is open), transistor T_1, whose base is linked to the switch, cuts off T_2, so that the interior light remains off.



When the switch closes (when the door is opened), the base of T_1 is at earth level and the transistor is off. Capacitor C_1 is charged fairly rapidly via R_3 and D_1, whereupon T_2 comes on so that the interior light is switched on.

When the door is closed again, T_1 conducts and stops the charging of C_1. However, the capacitor is discharged fairly slowly via R_5, so that T_2 is not turned off immediately. This ensures that the interior light remains on for a little while and then goes out slowly.

The time delays may be varied quite substantially by altering the values of R_3, R_5, and C_1.

Circuit IC_2 may be one of many types of n-channel power MOSFET, but it should be able to handle drain-source voltages greater than 50 V. In the prototype, a BUZ74 is used which can handle D-S voltages of up to 500 V.

[984065]

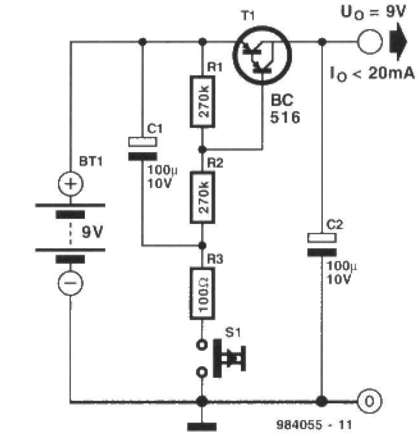
034 auto power off

Design: H. Bonekamp

We are surrounded by battery-operated equipment of all kinds, and this array is growing still. Manufacturers and designers lean over backwards to make sure that their equipment draws a small current and can thus be operated by a battery.

This has its flip side, too, because even if the equipment in question draws only a small current, when it is not switched off, the battery is flat after a few days or weeks. The circuit presented here can prevent this happening.

It may be added to all kinds of equipment operating from a 9 V battery and switches this off automatically one minute after a preset time has elapsed. The peak switching current is 20 mA, which is more than enough for most applications.



The switch is formed by a p-n-p darlington, T_1, which is actuated by push-button switch S_1. The very high amplification of the darlington enables it to be kept on fairly long with the aid of a relatively small-value capacitor, C_1 (= 100 μF). Resistor R_3 limits the charging current of C_1 to ensure a long life of S_1. Resistors R_1 and R_2, in conjunction with C_1, determine the switch-on time. When this time has elapsed, R_1 ensures that T_1 is switched off.

Since the darlington can handle a U_{BE} of –10 V, a polarity protection diode is not needed.

[984055]

035 pan pot

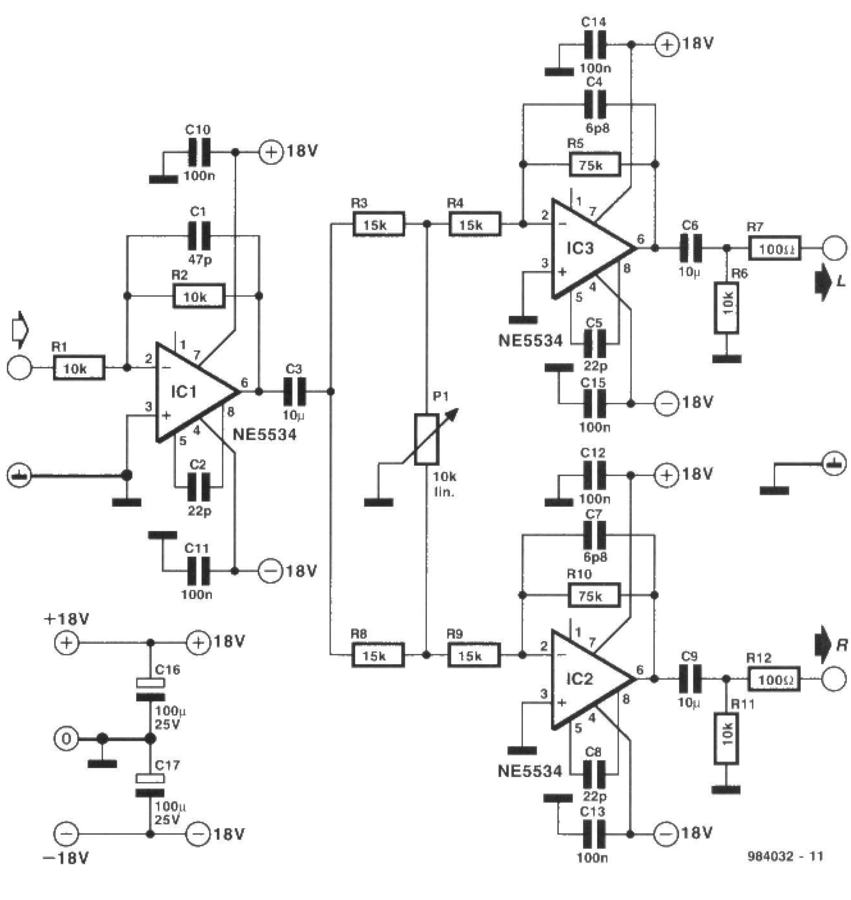
Design: T. Giesberts

A pan pot enables a monophonic input signal to be positioned where desired between the stereo loudspeakers. When P_1 (see diagram) is in the centre position, there is no attenuation or amplification between the input and output. When the control is turned away from the centre position, the signal in one channel will be amplified 3 dB more than the other.

Circuit IC_1 at the input is a buffer stage. It is arranged as an inverter to ensure that the phase of the input signal is identical to that of the output signal. The input impedance is set by R_1 (10 kΩ).

The output of the buffer is applied to stereo amplifiers IC_2 and IC_3. A special arrangement here is the positioning of P_1, in conjunction with R_3, R_4, R_8, and R_9, in the feedback circuits of both amplifiers. This means that any adjustment of the potentiometer will have opposite effects in the amplifiers.

Series resistors R_7 and R_{12} serve to ensure that the outputs can handle capacitive loads.



Coupling capacitors C_3, C_6, and C_9, may be omitted if an offset voltage of 20–30 mV is of no consequence in the relevant application.

Capacitors C_2, C_5, and C_8, ensure that the op amps remain stable even at unity gain.

Capacitors C_1, C_4, and C_7, minimize any r.f. interference, resulting in a usable bandwidth of 2.5 Hz to 200 kHz.

The performance of the circuit is of sufficiently high quality to allow the pot being incorporated in good-quality control panels.

Total harmonic distortion plus noise (THD+N) at a frequency of 1 kHz and a bandwidth of 22 kHz is 0.0014%. Over the band 20 Hz to 20 kHz and a bandwidth of 80 dB, this figure is still only 0.0023%.

The circuit needs a power supply of ±18 V, from which it draws a current of about 16 mA.

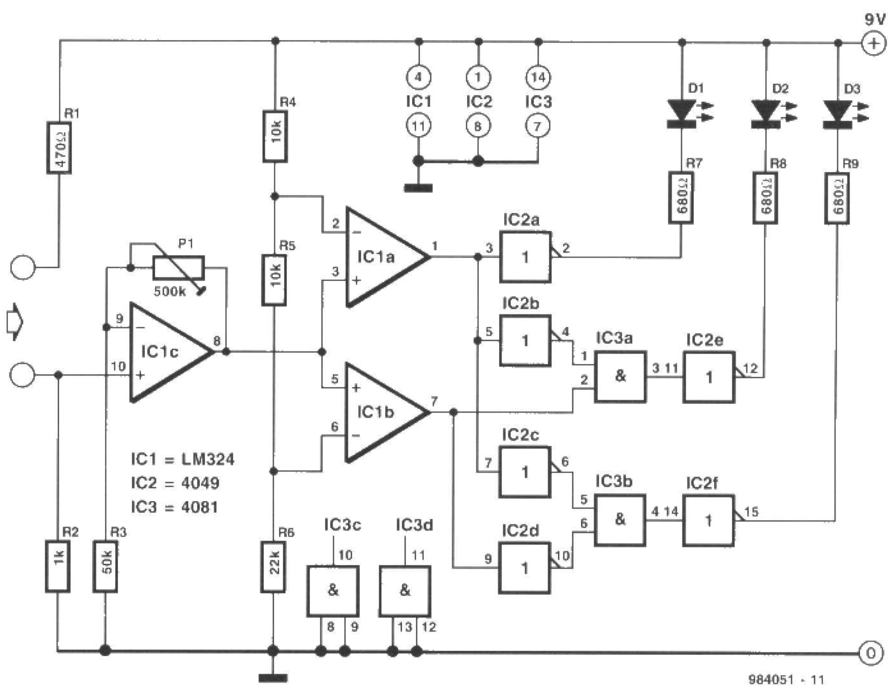
[984032]

036 three-state continuity tester

Design: P. Lay

The continuity tester can distinguish between high-, medium-, and low-resistance connections. When there is a conductance between the inputs, which are linked to small probes, a current flows from the +9 V line to earth via R_1 and R_2. The consequent potential difference, p.d., across R_2 is used to determine the transfer resistance.

Operational amplifier IC_{1c} amplifies the p.d. across R_2 to a degree that is set with P_1. A window comparator, IC_{1a} and IC_{1b}, likens the output of IC_{1c} to the two levels set with potential divider R_4–R_6. Depending on the state of the outputs of the two comparators, three light-emitting diodes (LEDs) are driven via the gates and inverters contained in IC_3 and IC_2 respectively in such a way that they indicate the transfer resistance in three categories. When the resistance is high, green diode D_3 lights; when it is of medium value, yellow diode D_2 lights, and when it is low, red diode D_1 lights. The levels at which the diodes light is set with P_1, but note that in any case the minimum value depends on the



p.d. across R_2.

It is possible to reduce the value of the p.d. to enable lower transfer resistances to be detected, but this would mean an increase in the test current through R_2.

With values as specified, the circuit in its quiescent state draws a current of about 17 mA, but in operation each LED adds about 10 mA to this.

The LM324 (IC_1) may be operated from a single supply line: R_1 prevents the voltage at the input from reaching the level of the supply line (which is not permissible).

The supply voltage may be 5–18 V. The LEDs are driven directly by the inverters in the 4049 (IC_2), which can switch currents of up to 20 mA to earth.

[984051]

037 automatic light dimmer

Design: Schallmoser

In many cases, the dimmer presented here may be built into a wall-mounted box containing the light switch. It is intended for use with 240 V incandescent lamps only.

When it is fitted, and the light is switched on, the lamp does not come on fully for about 400 ms (which is not noticeable). When the light is switched off, it stays on unchanged for about 20 s, and then goes out gradually. This has the advantage that it is not immediately dark when the light is switched off.

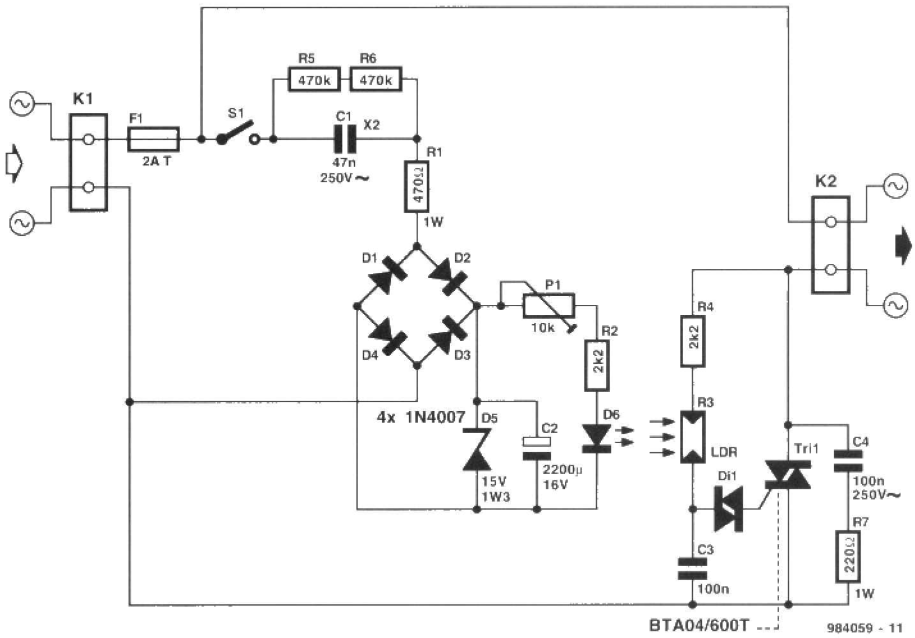
When light switch S_1 is turned on, capacitor C_2 is charged via R_1, C_1 and bridge rectifier D_1–D_4. Zener diode D_5 limits the potential across C_2 to about 15 V. After a short while, diode D_6 lights, whereupon a potential difference ensues across light sensitive resistor R_3, which is sufficient to trigger triac

Tr_1. The light then comes on.

When the light switch is turned off, C_2 is discharged via P_1, R_2 and D_6. When the potential across C_2 drops, the brightness of the LED diminishes, so that the p.d. across R_3 also drops. The increasing resistance of R_3 effects phase angle control of the triac so that the light is dimmed gradually. The dimming time may be altered with P_1 within the time range determined by network R_2-C_2.

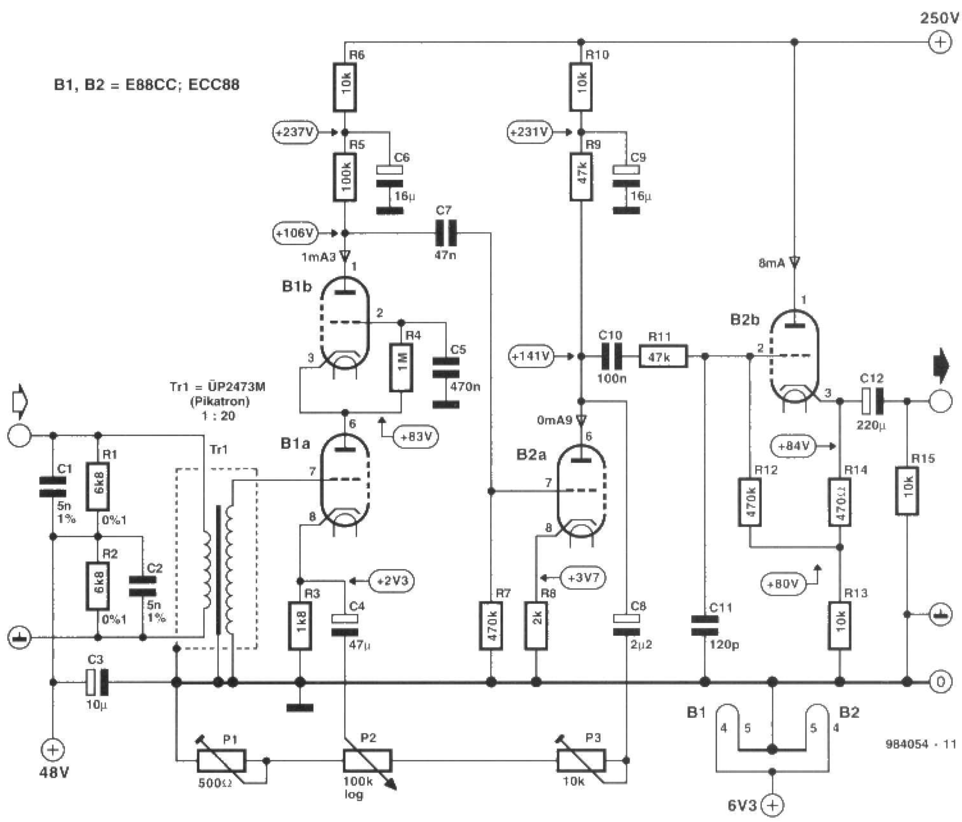
The circuit operates correctly only, of course, when the LDR is not exposed to light other than that from the LED.

The type of LDR is not particularly important, as long as it is not too long: in the prototype, a model with a length of 5 mm was used. [984059]



038 microphone valve preamplifier

Design: G. Corinth



To many hi-fi enthusiasts and musicians, the thermionic valve (electron tube), the sound of a valve amplifier cannot be bettered by that of a solid-state amplifier. To satisfy that conviction, here is a microphone preamplifier based on valves.

The circuit in the diagram is intended for use with a studio microphone with or without phantom supply.

The microphone output signal is applied to the control grid of V_{1A} via transformer Tr_1, which has a transformation ratio of 1:20. The input double triode, a Type ECC88 or E88CC is configured as a cascode circuit. This type of circuit has the high amplification of a pentode and the low noise of a triode.

The grid bias for V_{1B} is the potential drop across R_4, so that the operating point is established automatically.

The output of V_{1B} is applied to the control grid of V_{2A}. This half of another double triode Type E88CC or ECC88, is arranged as a straightforward voltage amplifier. Its output is applied to grounded-anode amplifier V_{2B}.

Power is supplied by a traditional valve circuit providing an anode voltage of 250 V and a heater (direct) voltage of 6.3 V. The heater voltage is stabilized by a solid-state variable regulator. The heater current is 600 mA. The anode current is about 15 mA.

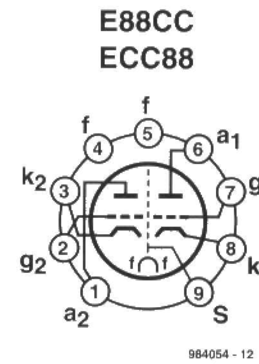
Building the amplifier is not specially difficult, as long as the usual care is taken, such as correct balancing and low-capacitance link from the secondary of Tr_1 to the grid of V_{1A}. The ratings of the various resistors and capacitors can be derived readily from the voltage and current values shown in the diagram.

Brief parameters

Frequency range	30–20,000 Hz ±3 dB
Distortion	
Maximum drive, a = 80 dB, 30–10,000 Hz	≤ 0.1%
Maximum drive, a = 40 dB, 30–80 Hz	≤ 0.2%
Maximum drive, a = 40 dB, 80–10,000 Hz	≤ 0.1%
Output voltage at maximum drive	8 V r.m.s.
Drive limit for k = 1%	
With a = 80 dB	+34 dBm (38 V r.m.s.)
With a = 40 dB	+25 dBm (13.5 V r.m.s.)
Noise output (input terminated by 200 Ω impedance)	
Weighted, a = 80 dB	–117 dB
Weighted, a = 40 dB	–116.6 dB
Unweighted, a = 80 dB	–128 dB
Unweighted, a = 40 dB	–127 dB
Common mode rejection	60 dB
Output impedance	
30–80 Hz	about 200 Ω
80–20,000 Hz	about 120 Ω

Preset P_1 is adjusted for an amplification $\alpha = \times 10^4$ (80 dB) and P_3 for $\alpha = \times 10^2$ (40 dB). The potential divider may also be constructed from fixed resistors, when P_1 = 130 Ω; P_3 = 8640 Ω; and P_2 = 549 Ω + 9760 Ω + 68100 Ω + 24100 Ω. Successive nodes in the chain represent 10 dB gain intervals so that gains of 40 dB and 80 dB respectively are set readily.

The microphone amplifier does not just meet the requirements of a good hi-fi unit, but satisfies those of professional audio equipment. In this context, measurements on the prototype were taken under the rules of professional equipment (source impedance = 200 Ω, load resistance = 5 kΩ). The results are shown in the table.

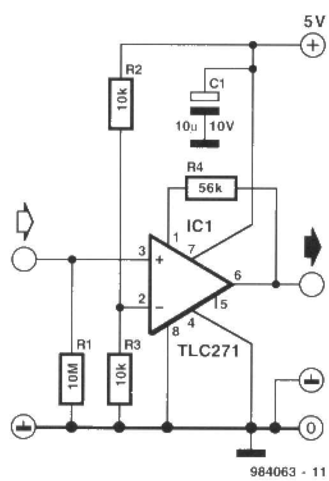


[984054]

039 op amp with hysteresis

Design: H. Bonekamp

At first glance, the circuit in the diagram does not look out of the ordinary, and yet, it is. This is because it combines two characteristics that are usually assumed to be incompatible: hysteresis and a high input impedance. In a standard op amp circuit, this is, indeed, true, because the creation of hysteresis is normally achieved by positive feedback to the +ve input of the op amp. Unfortunately, the requisite resistance network causes a drastic deterioration of the original high input impedance of the op amp.



So, when a high input impedance and hysteresis are wanted, the solution is to obtain the needed positive feedback by coupling the resistor network not to the +ve input but to the offset correction pin. When this done, the hysteresis so obtained is calculated from

$$U_h = 1.2/R_4U_o,$$

where U_h is the hysteresis voltage and U_o is the output voltage of the op amp, both in volts The value of R_4 must be in kΩ. The level of U_o depends, of course, on the load.

[984063]

040 sounds from the Old West

Holtek Application

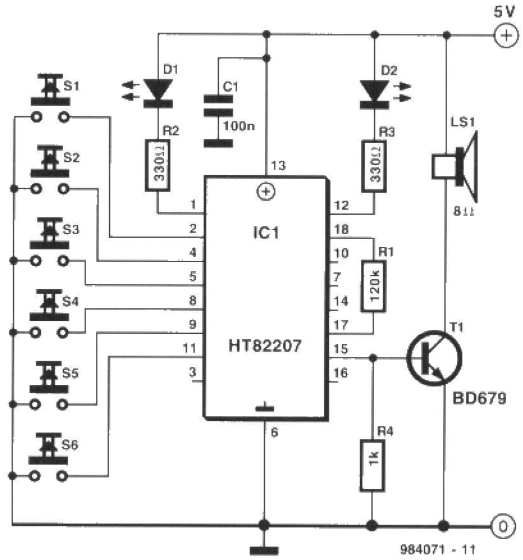
This circuit shows how far integration can be taken: IC_1, a Type HT82207 from Holtek does virtually everything. Only a (small) loudspeaker and the necessary selectors need to be added.

The standard 18-pin Type HT82207 is an integrated sound generator, producing sounds typical of the Old West. The various sounds are selected by S_1–S_6 as listed below.

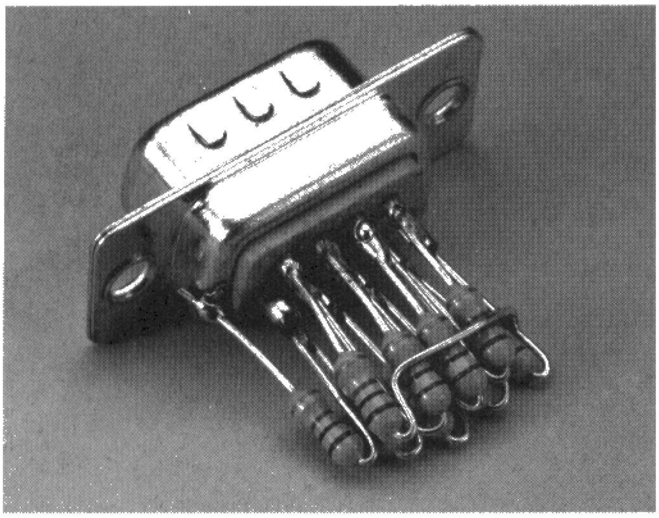
In the quiescent state, the circuit draws a current not exceeding 1 μA.

S_1 – bugle
S_2 – neighing
S_3 – sound of hooves
S_4 – pistol shot
S_5 – crack of a rifle
S_6 – cannon fire

[984071]



041 cable analyser



Orignal design: B. Vock
Modified by: S. Wolf

Many constructors have various cables lying around and after a time do not know any longer what they are for or what their pin connections are. It is not always possible to check this with a multimeter. The analyser may be of help in such a situation. In most cases, an analyser for checking cables with D9 and D25 connectors will suffice.

The shape of the analyser will depend to a large extent on the type of cable to be checked. It may be made as a connector, as a bus, or as a feed-through cable. Since only standard components are needed, the cost is low.

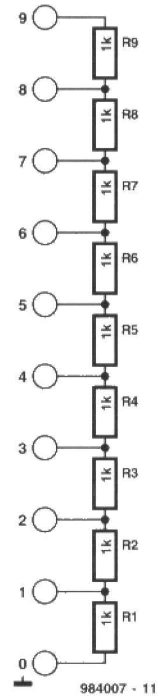
Solder a resistor of 1 kΩ between pin 1 of the analyser and the case; one of 2 kΩ between pin 2 and the case, and so on, increasing the value of the resistor by 1 kΩ for each successive pin.

When this is completed, connect the analyser to the cable to be tested and measure the resistance between pin 1 and the case. The value so obtained in kilohms is the number of the pin at the other end of the cable.

The arrangement is shown in the diagram. If at all possible, use resistors in the E96 series, since these give best accuracy.

[B. Vock – 974108]

Since this design was completed, a reader has suggested a simple improvement to it, whereby the nine resistors are linked in series instead of in parallel. The great advantage of this simplification is that all nine resistors have the same value: 1 Ω or 1 kΩ. The test method remains the same: the value in Ω or kΩ measured on the multimeter is the nuber of the pin at the other end of the cable.



[984007]

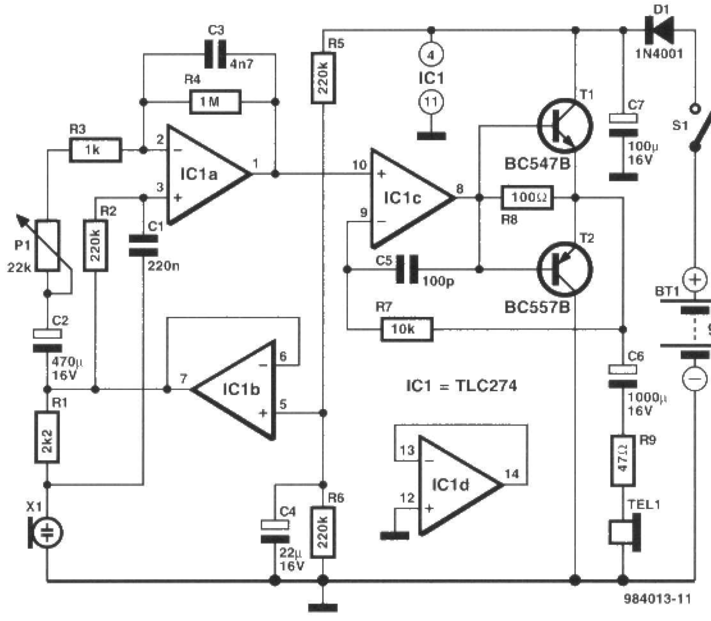
042 pulse rate monitor

Design: P. Lay

This simple circuit enables you to listen to your heartbeat, for instance, while you are exercising.

The transducer used for detecting the pulse is an electret microphone, X_1 in the diagram. The model used has two (polarized) terminals. As usual with this type of microphone, it functions via a series resistor, R_1. The potential drop across this resistor is applied to op amp IC_{1a} via C_1. The amplification of the op amp is set to between ×40 and ×1000 with preset P_1.

Network R_4-C_3 in the feedback loop of IC_{1a} is a low-pass filter with a cut-off frequency of 34 Hz. Higher frequencies are not needed for the present application. A pulse rate of 180* is



equivalent to a frequency of 3 Hz. So as to cater for a wide range of pulse rates, the cut-off frequency is made just over 11 times as high as that representing the highest pulse rate.

Operational amplifier IC_{1c}, in conjunction with push-pull am-plifier T_1-T_2, creates a headphone amplifier, whose output resistance is equivalent to the value of R_9, that is, 47 Ω. This makes the circuit usable for virtually any kind of headset. The output is short-circuit-proof. In case of certain headphones, such as that used with Sony Walkman™ sets, it is best to connect the two earphones in series.

Operational amplifier IC_{1b} is used as an active potential divider. The voltage across the actual divider, R_5-R_6, is half the supply voltage. This voltage is buffered by IC_{1b}, taken from the low-resistance output, pin 7, of this op amp and used as reference for IC_{1a}, and as operating voltage for the electret microphone. The voltage is decoupled by C_4 to remove any interference signals from it.

The supply voltage for the pulse rate monitor is decoupled by capacitor C_7, immediately after polarity protection diode D_1.

Owing to the use of CMOS op amps, the current drain does not exceed 10 mA, so that operation from a 9 V battery is perfectly feasible. A dry alkaline-manganese battery will have a life of about 50 hours.

[984013]

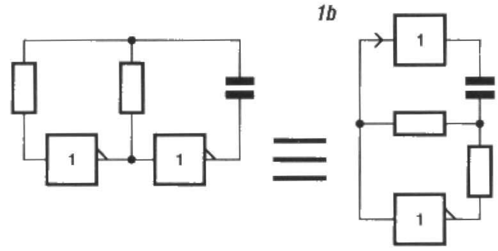
* *Unless you are a young superfit top-class athlete, you should see your GP immediately when you find you have a pulse rate of 180. As a general guide, the absolute maximum pulse rate for a young, very fit person is 180, for a middle-aged person, 160, and for an elderly person, 140. When exercising, the pulse rate of a not very fit person should not exceed 60% of these maxima.*

Editor

043 general purpose oscillator

1a

1b



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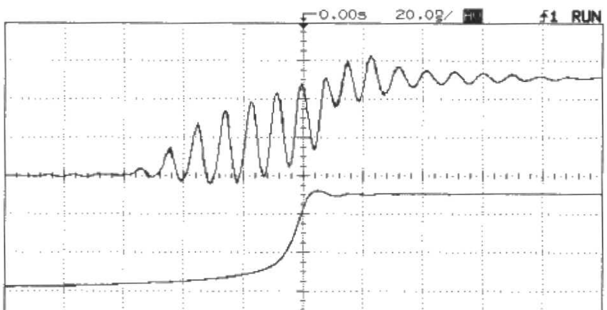

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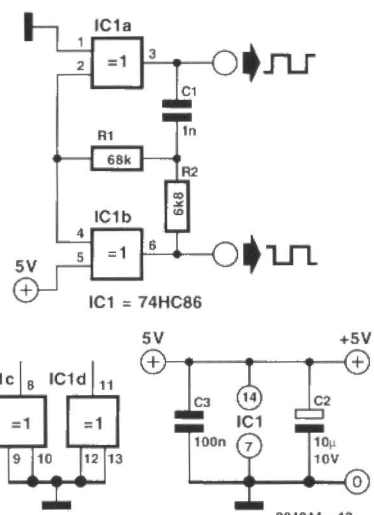
3



984044 - 13

Design: H. Bonekamp

The oscillator shown in Figure 1 is frequently used in digital circuits and may, therefore, look very familiar. Many readers may not know that this type of oscillator suffers from a nasty drawback caused by noise. When the amplitude of the noise is higher than the hysteresis of the gates used for the oscillator, spurious switching pulses are generated near the zero crossings. This problem can be cured only by ensuring that the rise time of the input signal is shorter than the reaction time of the relevant gate.

When the oscillator is built with fast logic gates, such as those in the HC-series, the likelihood of the problem occurring is great. However, as long as the positive feedback is fast enough, nothing untoward will happen. However, when delays occur owing to the transit time of the components used, the problem may rear its head.

In the configuration of Figure 1a, the signal passes through two inverters and thus experiences twice the transit time of a single gate. The upper signal in the oscilloscope trace in Figure 2 shows the result of this: the gates used are simply too fast for this type of oscillator. If one of the inverters is replaced by a buffer, and the oscillator is modified as shown in Figure 1b, the transit time is limited to that of one gate: the lower trace in Figure 2 shows that the oscillator then works correctly.

The practical circuit diagram of the general-purpose oscillator is shown in Figure 3. Note that two XOR gates are used to ensure that the transit time of the buffer is equal to that of the

044 Two-way AF amplifier LM4830

National Semiconductor Application

The LM4830, whose internal circuit is shown in Figure 1, is an integrated solution for two-way audio amplification. It contains a bridge-connected audio power amplifier capable of delivering 1 W of continuous average power to an 8 Ω load with less than 1% total harmonic distortion (THD) from a 5 V power supply.

The LM4830 also has the capability of driving 100 mW into a single-ended 32 Ω impedance for headset operation. There is a 30 dB attenuator in front of a bridged power amplifier with 6 dB of gain. The attenuation is controlled through 4 bits of parallel digital control; 15 steps of 2 dB each.

The device also contains a microphone preamplifier with two selectable inputs. Mic1 is selected when HS is high and A1 is in single-ended mode. Mic2 is selected when HS is low and A1 is in bridged mode. This configuration is optimum for switching between an internal system speaker and external headset with microphone.

The LM4830 also incorporates a buffer for driving capacitive loads.

The device provides a low-current drain shut-down mode making it optimally suited for low-power portable systems. In addition, the device has has an internal thermal shutdown protection mechanism.

As shown in **Figure 2**, amplifier A_1 can be used in one of two modes, bridged output or single-ended output. This also allows headphones to be driven single-endedly. The output can be switched automatically from bridged speaker drive to single-ended headphone drive using a control pin in the headphone jack that is tied to the HS (headset) pin 3. When the voltage at the HS pin input changes from 0 V to 5 V, V_{02} of the bridged amplifier output is put into high impedance. This allows the permanently connected internal speaker of the system to be disabled when a headphone is plugged into the headphone jack. Output V_{01} then drives the headphone single-endedly through the output coupling capacitor, C_C. This capacitor should be chosen to allow the full audio bandwidth to be amplified. Since C_C and R_L form a high-pass filter, the value of C_C must be high enough to allow frequencies down to 20 Hz to be amplified. The value is calculated from

$$C_C = 1/[2\pi(20\text{Hz})R_L] \qquad [1]$$

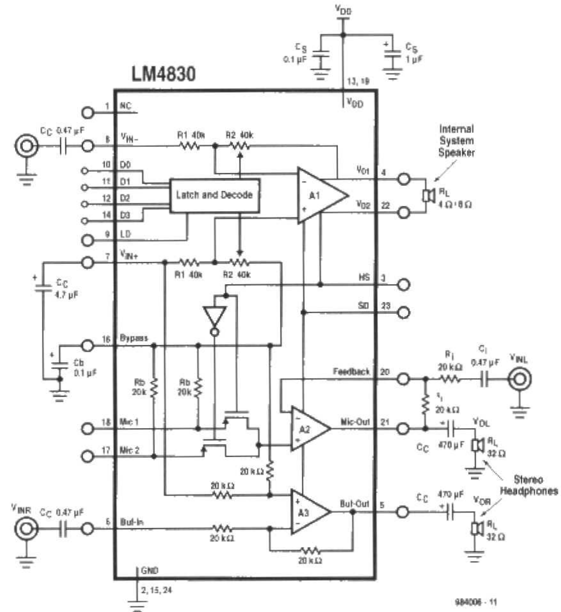
where $16\ \Omega \leq R_L \leq 600\ \Omega$.

The LD (load) pin 9 has two modes of operation. When this input is high, the power amplifier's attenuation control is in transparent mode, where the voltage on bits D_0–D_3 will cause the appropriate attenuation level to be latched and decoded within the IC. For normal attenuation, pin 9 should be at 5 V. When the pin is low, the power amplifier's attenuation control is locked out, so that any change in the input bits will not cause a subsequent change in the amplifier's attenuation level.

The attenuation level is preset to –16 dB when the IC is first powered up, assuming that pin 9 is low until the IC is fully biased up.

The preamplifier on this IC is intended for use as a microphone amplifier. Depending on the frequency response of the microphone, the preamplifier's response can be configured to fit the microphone. Simple capacitors can be used to limit the bandwidth of the frequency response of the preamplifier and improve the system's performance. Once the gain of the amplifier is chosen, te values of the resistors and capacitors can be selected with the following equations.

1



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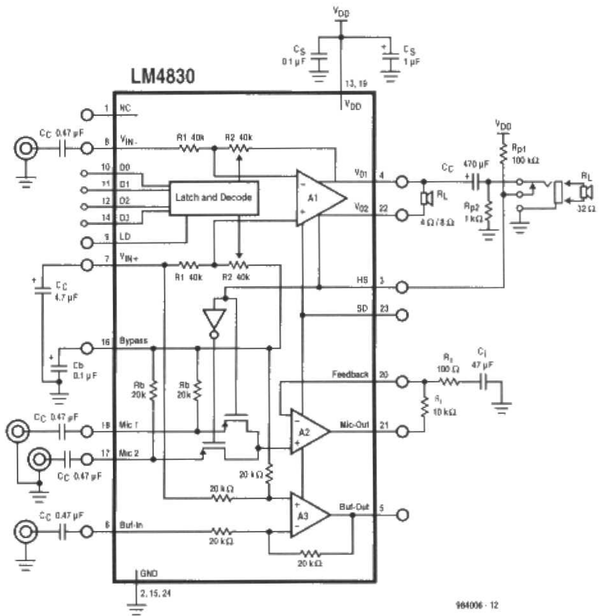


$$A_{VCL} = 1 + R_f/R_i \qquad [2]$$
$$f_{LP} = 1/2\pi R_f C_f \qquad [3]$$
$$f_{HP} = 1/2\pi R_f C_i \qquad [4]$$

As an example, assume that the desired closed-loop gain is 40 dB and the desired voice band, 300–3000 Hz. In Eq. 2, we choose R_f = 100 kΩ and R_i = 1 kΩ. The desired value in dB is equal to $20\log A_{VCL}$. Solving for C_f and C_i, using f_{LP} = 3 kHz and f_{HP} = 300 Hz, we obtain C_f = 530 pF and C_i = 0.53 μF.

[984006]

045 game control adaptor

From an idea by G. Scheibe

Most modern PCs are provided with a 15-way game port. This contains four digital inputs for the buttons and four analogue inputs for the potentiometers in the analogue joysticks. Bear in mind, however, that there are also I/O cards on the market with only one game port.

The joystick inputs are based on a monostable multivibrator whose on-time is set with a 100 kΩ external potentiometer as shown in **Figure 1**. This property may be used to convert the game port for measuring analogue phenomena via, say, an NTC (negative temperature coefficient) resistor, a PTC (positive temperature coefficient) resistor, or an LDR (light-dependent resistor).

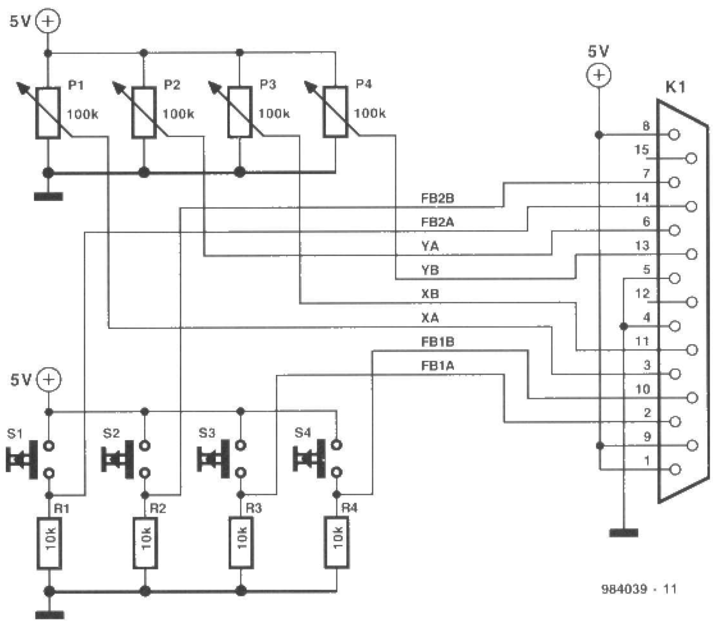
The software for reading the game port is relatively simple. A byte should be read at address 201_H (see **Figure 2**). The four MSBs (most significant bits, i.e., bits 7–4) at this address give the status of the four buttons. The four LSBs (least significant bits, i.e., 3–0) are high only during the mono on-time.

The software must determine the time during which a bit is high via a fast loop. The analogue value is derived from the pulse width. The faster the loop, the more accurate the measurement.

The listing shows a Pascal program with which up to four analogue levels can be measured.

(984039)

1



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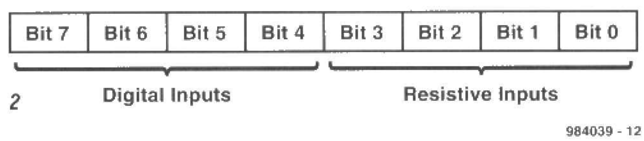



```
{######################## Analog Game Port ################################
# Example how to use an analog game port as analog input                  #
# Copyright 1998 Segment B.V., Beek, The Netherlands                      #
###########################################################################}

program gametest;

uses crt;

const g_port = $201;          {game port's base address}
      max = 550;              {holds maximum value}
      offset = 50;            {holds minimum value}
      nr = 5;                 {number of samples to average}
{######################## Measurement function ###########################}
function measure (var Value: integer; Input, Nr: integer):boolean;
{ 'Value' contains the result of the measurement
  'Input' selects the input channel
  'Nr' determines the number of samples used for averaging}

var i, counter, game : integer;
    bitgame : boolean;
    dummy : longint;

begin
     if ((nr > 100) or (input>4) or (input<1)) then
     begin
          gotoxy(5,20);
          writeln('Error!! Wrong parameter in measurement function');
          measure:=false;
     end
     else
```

```
      begin
           value:=0;
           dummy:=0;
           if input=4 then input:=8;
           if input=3 then input:=4;
           for i:=0 to (Nr-1) do
           begin
                counter:=0;
                bitgame:=true;
                port[g_port]:=0;
                while bitgame do
                begin
                     game:=port[g_port];
                     bitgame:=(((game and input)=input) and
                                      (counter<((max*2)+offset)));

                     counter:=counter+1;
                end;
                counter:=counter-offset;
                dummy:=(dummy + counter);
                delay(1);
           end;
           value:=trunc (dummy/Nr);
           if ((value> (max * 2)) or (value<0)) then
           begin
                if value<0 then value:=-9999
                else value:=9999;
                measure:=false;
           end
           else measure:=true;
      end;
end; {function}

{######################## Input fire button status #########################}
procedure buttons(var key1, key2, key3, key4: boolean);

{returns boolean values to show fire button status}
{keyx := true if button pressed}
var game : integer;

begin
     game := port[g_port];
     key1:=((game and 128)<>128);
     key2:=((game and 64)<>64);
     key3:=((game and 32)<>32);
     key4:=((game and 16)<>16);
end; {procedure}

{######################## Main Program ######################################}
var connect, i : integer;
    value1 : integer;
    returnm, t1, t2, t3, t4 : boolean;
    e : char;
    value2 : real;

begin
     ClrScr;
     gotoxy(5,3);
     writeln('Analog game port input');
     gotoxy(5,23);
     writeln('Press "e" to interrupt this program');
     gotoxy(1,8);
     writeln ('     INPUT 1:');
     writeln ('     INPUT 2:');
     writeln ('     INPUT 3:');
     writeln ('     INPUT 4:');
     gotoxy(5,15);
     write('digital inputs:');
     gotoxy(12,17);
     write('1:');
     gotoxy(22,17);
     write('2:');
     gotoxy(32,17);
     write('3:');
```

```
      gotoxy(42,17);
      write('4:');
      while e<>'e' do
      begin
           if keypressed then e:=readkey
           else
           begin
                for i:=0 to 3 do
                begin
                     returnm := measure(value1, (i+1), Nr);
                     if returnm then
                     begin
                          gotoxy(30,(8+i));
                          write('         ');
                          gotoxy(30,(8+i));
                          write(value1);
                          gotoxy(35,(8+i));
                          write(' number of program loops ');
                     end
                     else
                     begin
                          gotoxy(30,(8+i));
                          if value1<0 then
                             write('----  negative overflow                        ')
                          else
                             write('++++  positive overflow                        ');
                     end;
                end;
                buttons(t1,t2,t3,t4);
                gotoxy(15,17);
                if t1 = true then
                   write(' ON')
                else
                    write('OFF');
                gotoxy(25,17);
                if t2 = true then
                   write(' ON')
                else
                    write('OFF');
                gotoxy(35,17);
                if t3 = true then
                   write(' ON')
                else
                    write('OFF');
                gotoxy(45,17);
                if t4 = true then
                   write(' ON')
                else
                    write('OFF');
           end; {else}
      end; {while}
      ClrScr;
end.
```

046 Centronics in system programmer

Design H. Bonekamp

The programmer is based on an AT89S8252, which is an 8052-derived IC with a flash ROM of 8 Kbyte and a data EEPROM of 2 Kbyte. The ROM is to be programmed >1000×, and the EEPROM >100,000×.

Programming is carried out via only four lines available via the Centronics port. This is possible because the interface already uses the requisite TTL levels. The lines should be not longer than 1.5 m (5 ft) to ensure reliable operation.

To prevent a phantom supply arising between the IC and the Centronics port, the programmer should be connected to the PC only when both systems are on.

DOS software, called CISP, has been specially developed for programming the IC. The program is enabled via a batch file with parameters (see help CISP /? for the available options) or via its own menu (start up with CISP.EXE).

The software can program and read the internal memory of the processor. It can also be used to enable two protection bits. Both the input and output files are in Intel hex format.

The software is written in C

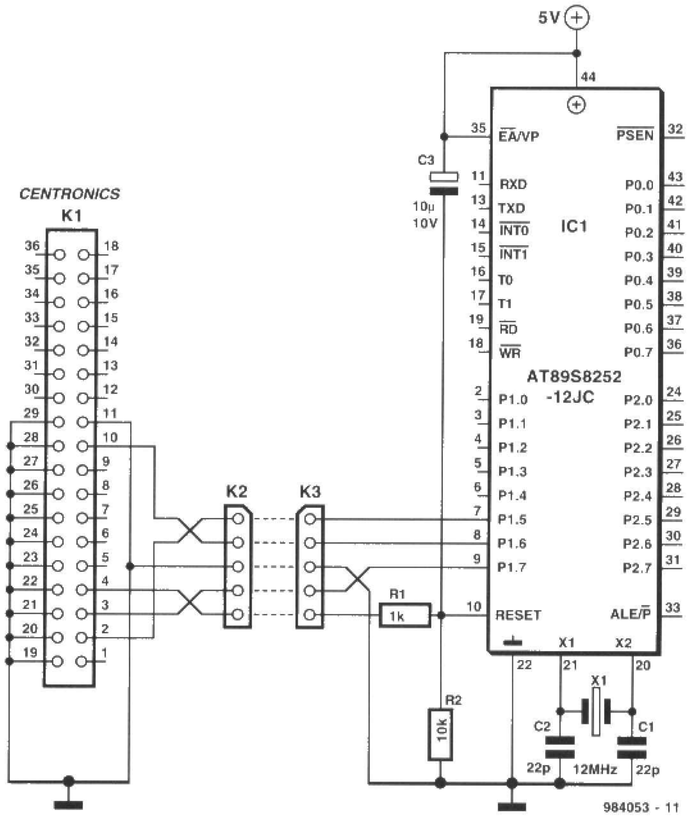
and the source file is available together with the EXE code on a 3.5 in floppy disk (Order no. 986023-1 – see Readers services towards the end of this issue).

The circuit as shown enables the software to be checked at an early stage. When the software is writing to a port or is verifying the content of one or more registers, a temporary address is set in the EEPROM during the test phase. The content of this address can be read and, if necessary, modified relatively easily.

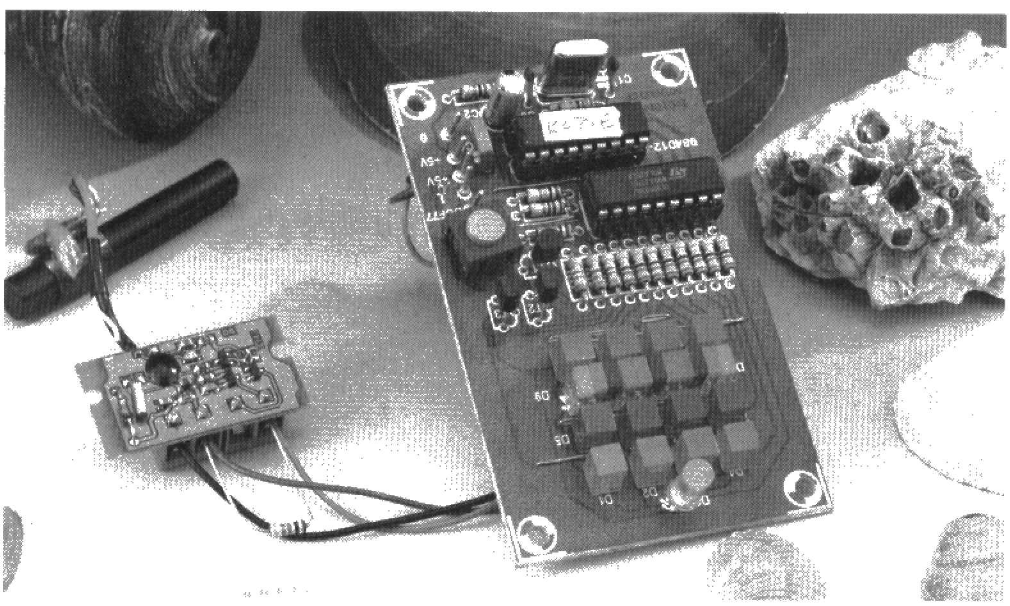
Make sure when purchasing the IC to get a version with the suffix H (or higher letter), since older versions suffer from small errors in the programming protocol.

The IC shown in the diagram is a 44-pin PLCC version. It is also available in a 40-pin DIL case, but bear in mind that the pinouts of the two are different.

[984053]



047 Berlin clock



Design M. Raschke

What is special about the Berlin clock, which, as its name implies, is situated in Berlin, and was erected in the early 1970, is that it shows the time by a row of lights that show the following (from top to bottom): seconds, five hour, hours, five minutes, and minutes—see **Figure 1**. A total of 24 lamps are used, which in the present circuit (**Figure 2**) are replaced by light-emitting diodes D_1–D_{24}. Diode D_{24} is the seconds indicator, D_{20}–D_{23} the minutes indicator; D_9–D_{19} the five-seconds indicator; D_5–D_8 the hours indicator, and D_1–D_4 the five-hours indicator.

The actual clock circuit consists of PIC microcontroller IC_1 and eight-fold buffer/inverter IC_2, which functions as the LED driver.

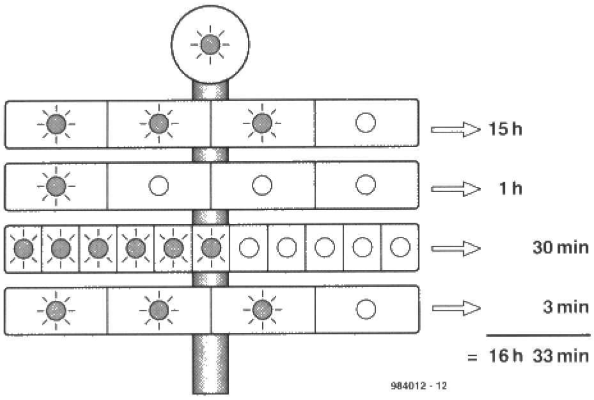
The clock may run on its own or in synchrony with a DCF77 receiver. When it runs on its own, its time base is formed by the crystal oscillator in IC_1. When synchronized with the DCF77 signal, it can be fine tuned by a trimmer capacitor in place of capacitor C_1 shown.

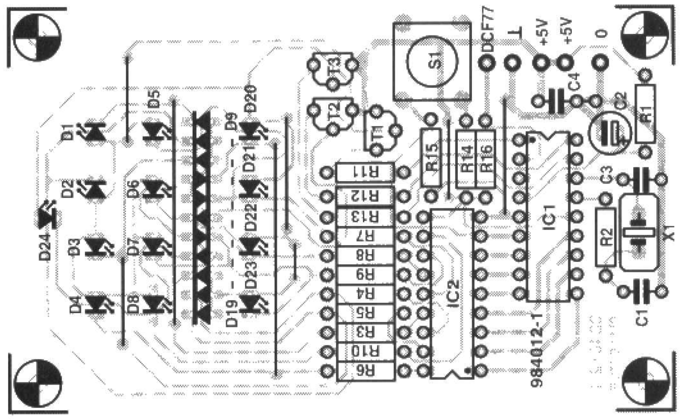
The DCF77 receiver may be any proprietary receiver module that runs from a 5 V supply and has a TTL output (low below 1 V, high above 2 V) that is high in the quiescent state. The open-collector output of the module used in te prototype may be inverted or non-inverted. In the present circuit, the inverted output (pin 4) is used, which is linked to the DCF pin on the PCB shown in **Figure 3**, and thus connected to the +5 V line via pull-up resistor R_{16}. Power for the module is taken from pins 'earth' and +5 V on the board.

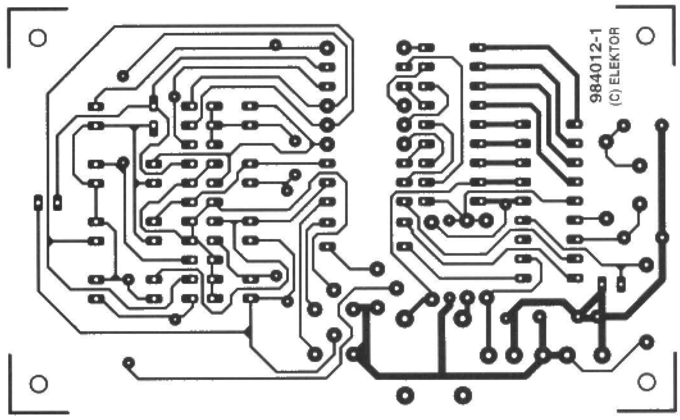
When populating the board, pay particular attention to the polarity of the LEDs: these are not all soldered in the same way.

When the finished clock is powered up, the display flashes at a rate of 1 Hz to indicate that the time shown is not correct. If the clock is run on its own, the time is set as follows:

1







- Press S_1 until the five-hours indicator flashes briefly (1s< t <2s).
- Press S_1 briefly a number of times until the correct number of five-hour LEDs flashes (t<1s).
- Keep S_1 pressed until the hour indicator flashes briefly (1s<t<2s).
- Press S_1 briefly a number of times until the correct hour LED flashes.
- And so on ...

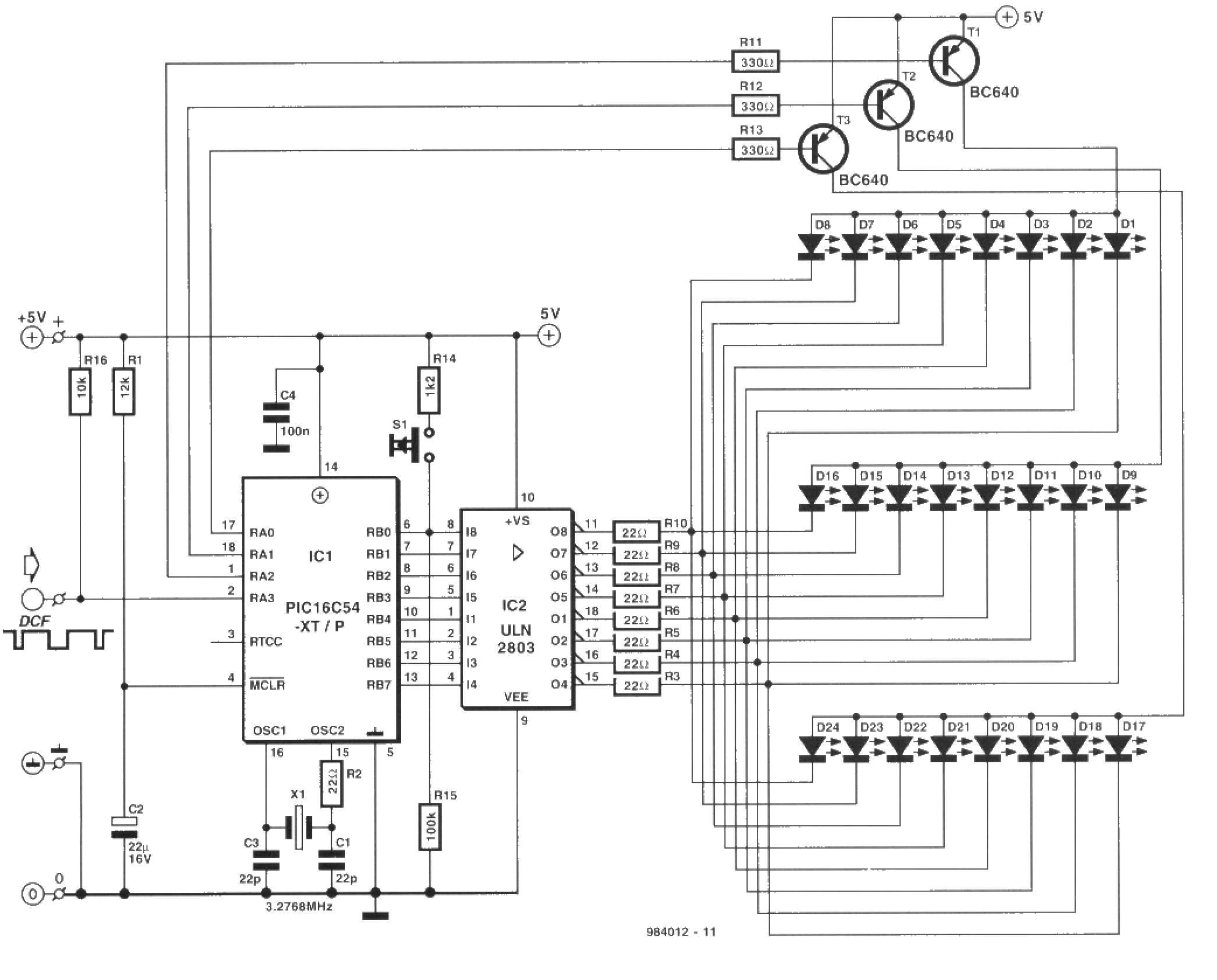
The setting is completed when the minute indicator flashes and S_1 is pressed longer than 1s (1s<t<2s). The display should then light and show the correct time of day.

When the clock is driven by a DCF77 receiver, S_1 is not required.

The clock is best powered by an appropriate, regulated mains adaptor that provides an output voltage of 5 V and an output current of up to 500 mA.

[984012]

2



Parts list

Resistors:
R_1 = 12 kΩ
R_2–R_{10} = 22 Ω
R_{11}–R_{13} = 330 Ω
R_{14} = 1.2 kΩ
R_{15} = 100 kΩ
R_{16} = 10 kΩ

Capacitors:
C_1, C_3 = 22 pF
C_2 = 22 μF, 16 V, radial
C_4 = 0.1 μF

Semiconductors:
D_1–D_8 = Led, red, 5×5 mm
D_9, D_{10}, D_{12}, D_{13}, D_{15}, D_{16}, D_{18}, D_{19} = LED, yellow, 5 × 2.5 mm
D_{11}, D_{14}, D_{17} = LED, red, 5 × 2.5 mm
D_{20}–D_{23} = LED, yellow, 5 × 5 mm
D_{24} = LED, yellow, 5 mm dia.
T_1–T_3 = BC640

Integrated circuits:
IC_1 = PIC16C54-XT/P (programmed Order no. 986508; see Readers Services towards the end of this issue)
IC_2 = ULN2803

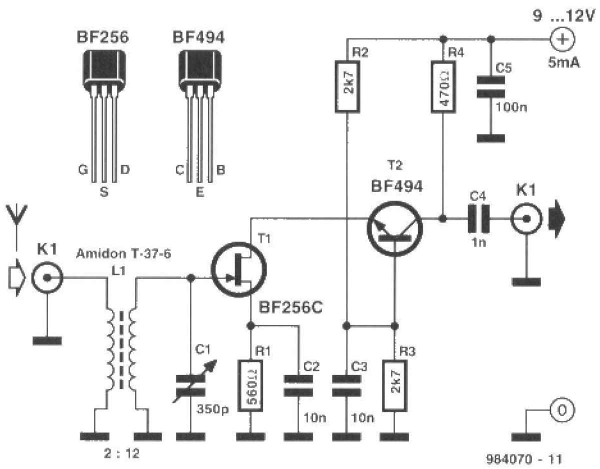
048 active short-wave antenna

Design: G. Pradeep

The circuit presented here illustrates the fact that in spite of all kinds of new component and technology, it is still possible to design useful, and interesting, circuits.

The circuit is based on two well-established transistors, a Type BF256C and a BF494. In conjunction with the requisite resistors and capacitors, these form a well-working antenna amplifier. Note that they are direct coupled.

Transistor T_1 is the input amplifier cum buffer, while the BF494, in a common-ground configuration, provides the necessary amplification.



The amplifier is designed for operation at frequencies between 10 MHz and 30 MHz, which is the larger part of the short-wave range, and has a gain of 20 dB.

Inductor L_1 is wound on an Amidon core Type T-37-6. The primary consists of 2 turns, and the secondary of 12 turns 0.3 mm dia. enamelled copper wire. The number of turns may be experimented with for other frequency ranges.

The input circuit is tuned to the wanted station with capacitor C_1. The response of the tuned circuit is fairly broad, so that correct tuning is easy.

The circuit is powered by a well-decoupled mains supply converter that has an output of 9–12 V. The circuit draws a current of about 5 mA.

[984070]

049 reflector for pedestrians

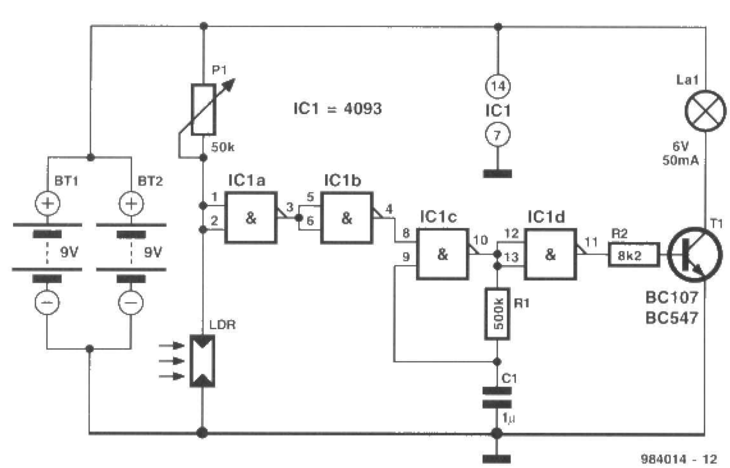
Design: P. Lay

Pedestrians run grave dangers when, in badly-lit areas, they cross a road at night in dark clothing, because this means that car drivers may see them too late There are special armbands available that reflect the light of oncoming traffic, telling the driver that there is someone on the road.

It is also possible to make an active means of warning car drivers or motorcyclists that you're crossing the road. It consists of a flat enclosure that houses two PP3 (6AM6; MN1604; 6LR61) 9 V batteries, and the small circuit shown in the diagram.

Glue a piece of self-adhe-

2



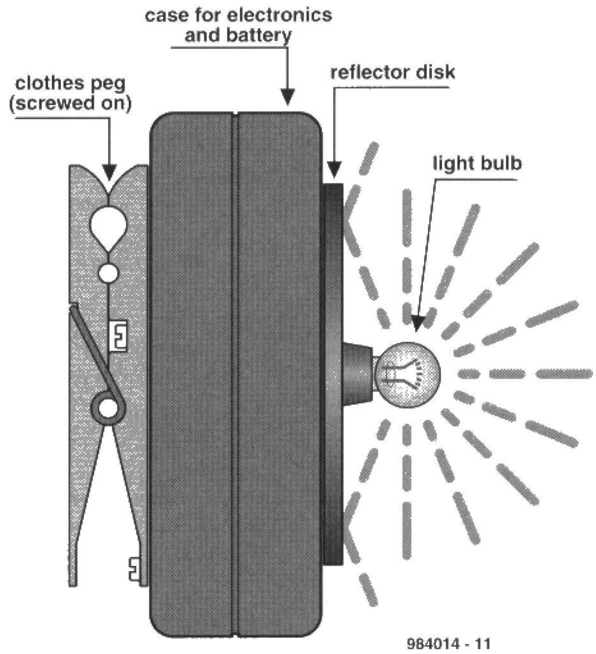
sive, reflecting tape (available in the motor trade) on the lid of the enclosure and drill a 10 mm hole in the centre of it. Fit a 6 V bulb in a suitable holder in the 10 mm hole. Fit a suitable clip and, optionally an on/off switch, at the rear of the enclosure. See Figure 1.

The electronic circuit consists of a light-sensitive switch, composed of P_1, a photoconductive cell, LDR, and IC_{1a}; an inverter, IC_{1b};, an oscillator, IC_{1c} with R_1 and C_1; a buffer, IC_{1d} with R_2 and T_1; and a 6–9 V bulb that draws a current of not more than 50 mA.

The photoconductive cell (or light-sensitive resistor) should be exposed to ambient light, but not to the light bulb, of course. Its sensitivity is set with P_1.

When the ambient light causes a potential drop across the LDR that is below the level set with P_1, IC_{1a} changes state, so that its output goes low, whereupon the output of IC_{1b} goes high, which actuates the oscillator. The buffer then switches the light bulb on and off in the rhythm of the oscillator.

1



Optionally, the light bulb may be replaced by a light-emitting diode rated at 1 cd or higher, and bias resistor. Make sure, however, that the current through the transistor does not exceed its rating of 50 mA.

The two 9 V batteries should be connected in parallel. The circuit needs a supply of 3–12 V.

[984014]

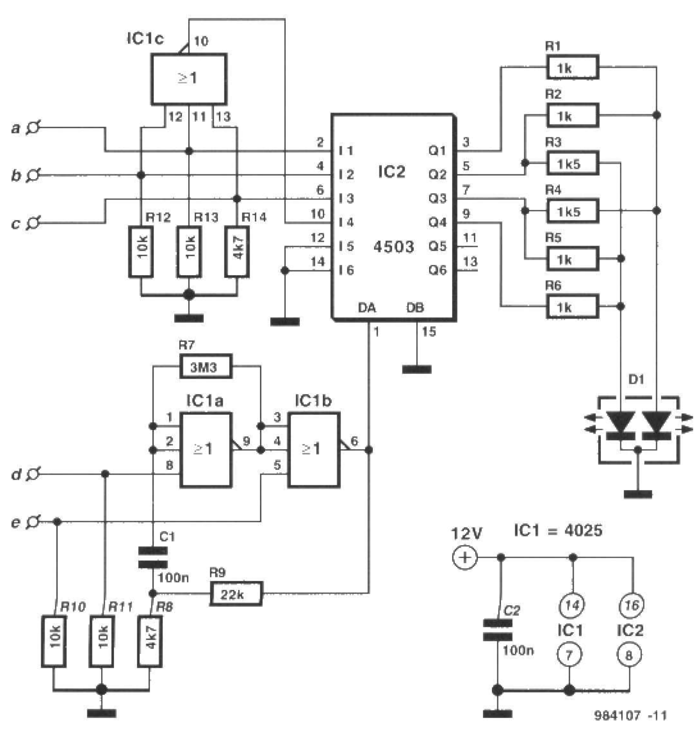
050 multi-colour LED

Design: V. Mitrovic

How many different conditions do you reckon may be signalled with just one LED? Two, maybe three? Using this simple circuit, a lot more!

Admittedly, a two-colour LED is used here. Such a device consists of two light-emitting chips, usually red and green, encapsulated in the same case. It has three pins: two for the anodes, and one for the common cathode. In this way, each diode can be activated separately. Various mixed colours may be obtained by varying the current through the two diodes. At least four discrete colours are then easily perceived: pure red, pure green, orange (I_R = $2I_G$) and yellow (I_G = $2I_R$).

In the present circuit, the LED elements are driven by CMOS three-state buffers type 4503, which, unlike most CMOS ICs from the 4000 series, are capable of supplying up to 10 mA of output current. The LED currents are limited by resistors R1 through R6, whose values invite experiments with brightness and colours according to your own taste.



The circuit was originally developed to indicate the state of three inputs, a, b, and c (non-binary, i. e., only one of these is at 1 at any time), with the configuration (a=b=c=0) representing the fourth state. The latter is decoded by NAND gate IC1. An additional effect is produced by gates IC1a and IC1b, which are connected up into an oscillator circuit producing approximately two pulses per second. These pulses are used to control the common-enable input, DA (pin 1) of the 4503, so as to produce a flickering effect. The oscillator is controlled by means of inputs 'd' and 'e'. Pulling both of these logic high disables the oscillator and the LED driver. With e=0 and d=1 the outputs of the 4503 are switched to three-state, and the circuit is in power-down standby mode.

Although designed for a 12-V supply voltage, the circuit will happily work at any supply voltage between 5 V and 16 V. Nonused inputs of CMOS ICs must, of course, be tied to ground via 10-100 kΩ resistors.

(984107-1 LL)

051

NiCd battery charger

Design: K. Walraven

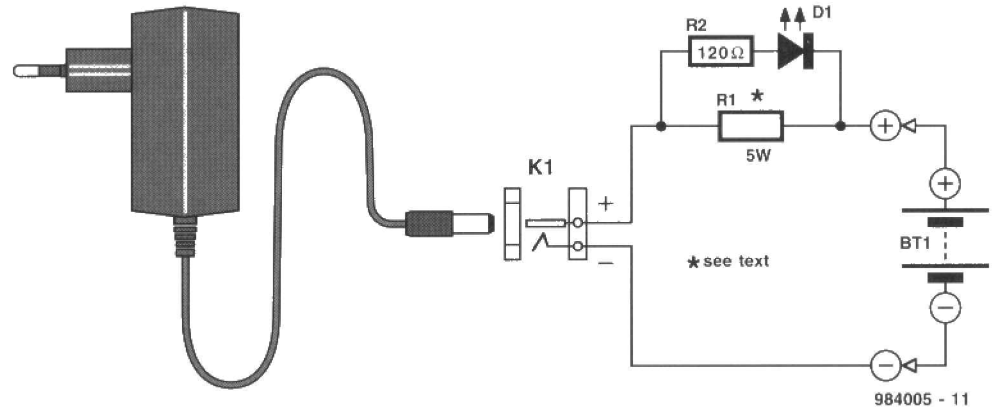
The design of the charger is similar to that of many commercially available chargers. The charger consists of a mains adaptor, two resistors and a light-emitting diode (LED). In practical use, this kind of charger is perfectly all right.

Resistor R_1 serves two functions: it establishes the correct charging current and it drops sufficient voltage to light the diode. This means that the LED lights only when a charging current flows into the battery. The charging current is about 1/4 of the battery capacity, which allows a slight overcharging, and yet the charging cycle is not too long (4–5 hours).

The value of the resistors may be calculated as follows, for which the nominal e.m.f. and the capacity of the battery must be known.

Adjust the output of the mains adaptor to 1.17 times the nominal battery voltage plus 3.3 V, which is the potential across R_1. Note that the adaptor must be capable of supplying a current of not less than half the battery capacity.

The value of R_1 in ohms is equal to 3.3 divided by 1/4 of the battery capacity. The value of the resistors for various battery voltages is given in the Table. The battery capacity is taken as 1 Ah. The rating of R_1 should be 5 W. If the battery to be charged has a different capacity, the theoretical value of R_1 in the table must be divided by the battery capacity. Its actual value is the nearest one in the E12 series. For instance, if a 6 V battery with a nominal capacity of 600 mAh is to be charged, the value of R_1 must be $20/0.6 = 33\ \Omega$.



Battery voltage (V)	1.2	2.4	3.6	4.8	6.0	7.2
Minimum voltage (V)	4.7	6.1	7.5	8.9	10.3	11.7
Adaptor voltage (V)	4.5	6.0	7.5	9.0	12	12
Value of R1 (theoretical) (Ω)	12.4	12.8	13.2	13.6	20	14.4
E12 value of R1 (Ω)	15	15	15	15	22	15
Value of R2 (Ω)	120	120	120	120	240	120

[984005]

052

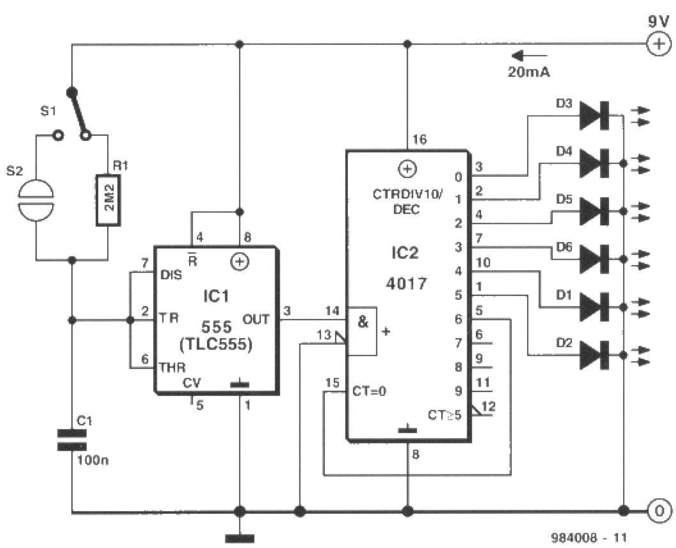
6-channel running light

Design: L. v/d Heeden

The circuit of the running light comprises two integrated circuits (ICs), a resistor, a capacitor and seven light-emitting diodes (LEDs). Decade scaler IC_2 ensures that the LEDs light sequentially. The rate at which this happens is determined by the clock at pin 14.

The clock is generated by IC_1, which is arranged as an astable multivibrator. Its frequency is determined by R_1-C_1.

The touch switch, consisting of two small metal disks is optional. When switch S_1 is in position 'off', the circuit may be actuated by the touch switch. By the way, this enables the circuit to be used as an electronic die (in which case the LEDs have to be numbered from 1 to 6).

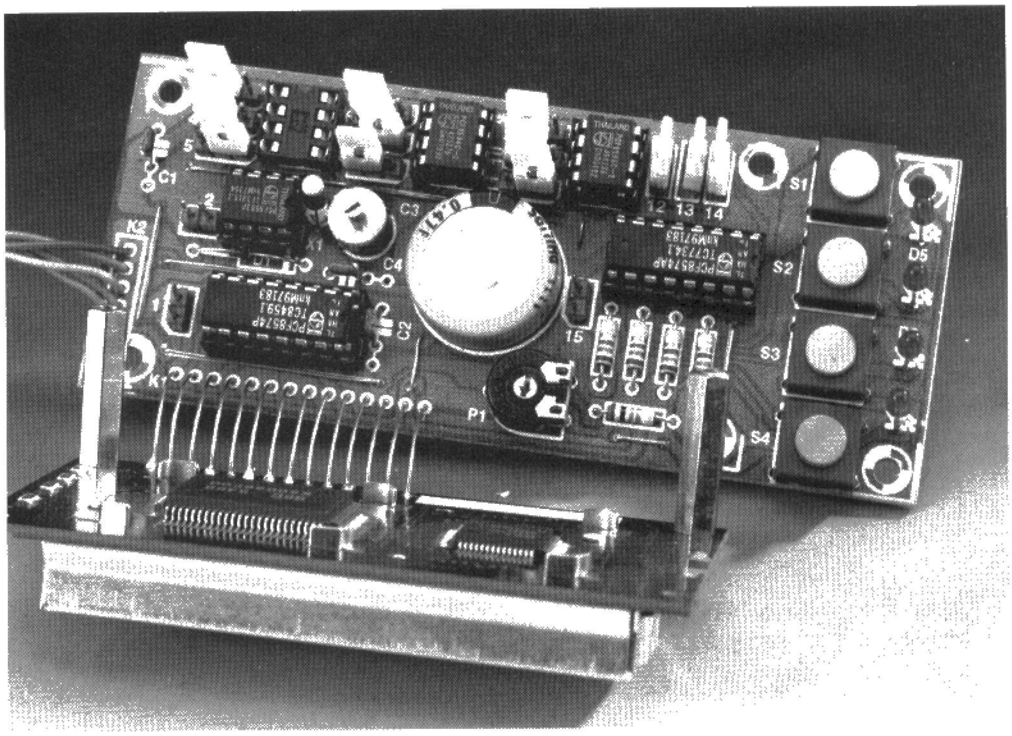


The running light is powered by a 9 V battery or mains adaptor. It draws a current not exceeding 20 mA.

[984008]

053 extension board for MatchBox BASIC computer

Design: K. Walraven



The MatchBox BASIC computer is without doubt one of the most popular projects published in *Elektor Electronics*. Meanwhile, the articles which appeared in the magazine on this little computer have been complemented by a book.

The printed circuit board presented here contains the following building blocks: a memory extension, a real-time clock, an alphanumerical LC display and an 8-bit I/O port. Although the port lines are shown here as connected to four LEDs and four push-buttons, the port may be used with many other configurations.

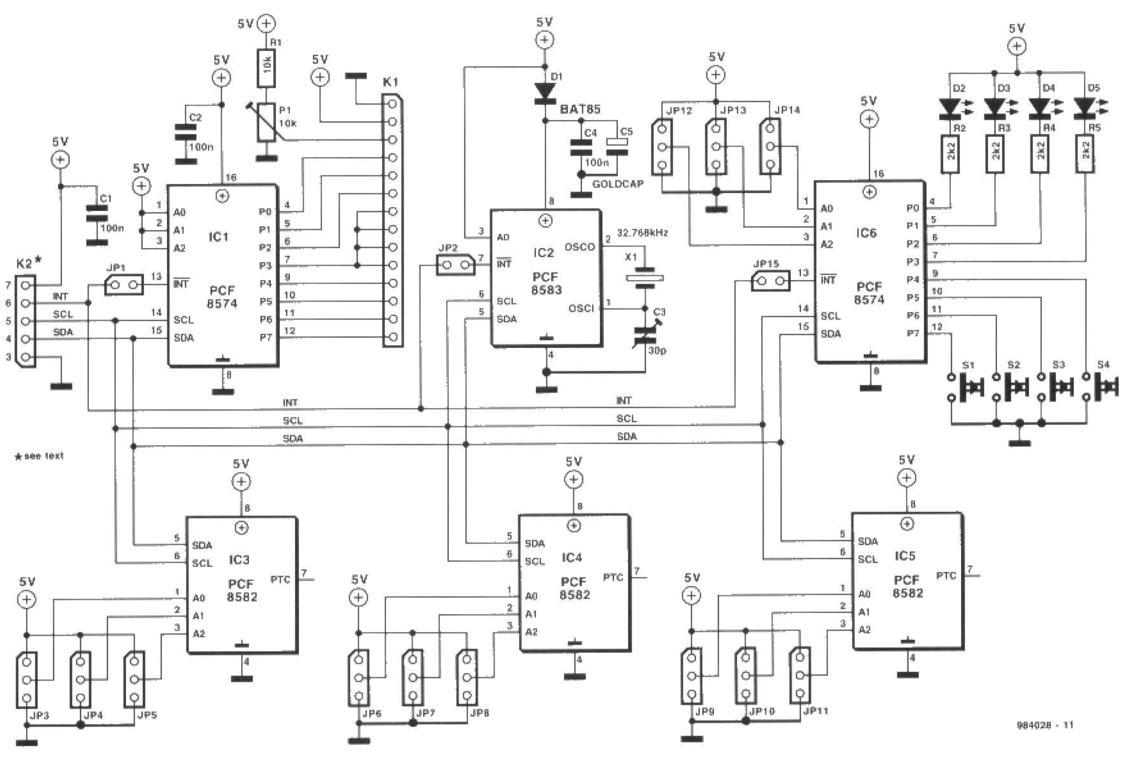
The hardware used on the extension board is based on the examples discussed in the above-mentioned book. The same goes for the software examples, which are directly suitable for use with the present extension board. Five connections have to be made between connector K2 on the extension board and K3 of the MatchBox computer board.

With the present extension board connected to the main MatchBox board, the memory structure of the computer is modified, mainly as a result of the clock being addressed in the memory range. The optimum memory allocation is then as follows:

- 256 bytes (PCF8582) on the MatchBox board, to which are added
- 512 bytes (PCF8594C-2, A2, A1, A0 = 010) and
- 1024 bytes (PCF8598C-2, A2, A1, A0 = 100) on the extension board

The available space for programs in the memory is then 1.5 kBytes.

If the Xicor 24C04 or 24C08 are used for the memory, then pin 7 has to be connected to ground via a small wire at the underside of the board. With the Philips



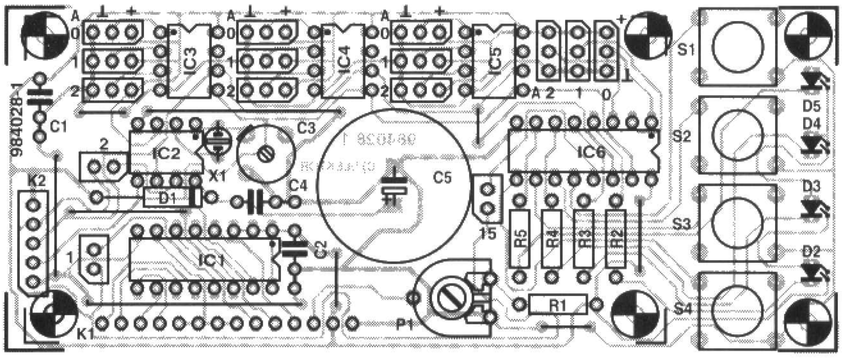
COMPONENTS LIST

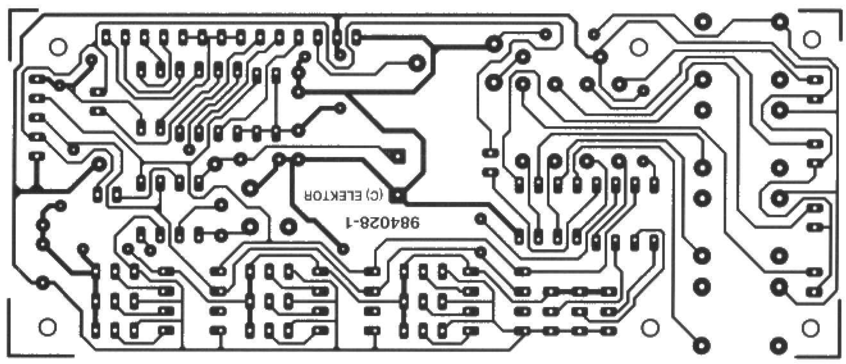
Resistors:
R1 = 10kΩ
R2-R5 = 2kΩ2
P1 = 10kΩ preset H

Capacitors
C1,C2,C4 = 100nF
C3 = 30pF trimmer
C5 = GoldCap 0.47F or 1F; 5.5V

Semiconductors:
D1 = BAT85
D2-D5 = LED, high efficiency
IC1 = PCF8574P
IC2 = PCF8583P
IC3,IC4,IC5 = PCF8582P, PCF8594C-2 or PCF8598C-2
IC6 = PCF8574P or PCF8574AP

Miscellaneous:
X1 = 32.768 kHz quartz crystal
JP1,JP2,JP15 = 2-way SIL pinheader with jumper
JP3-JP14 = 3-way SIL pinheader with jumper
S1-S4 = push-button, CTL3 (Mec)
K1 = 14-way SIL pinheader
K2 = 5-way SIL pinheader
PCB, order code 984028-1





versions, for which the board has been designed, the same pins are not connected.

The LC display is mounted on to the board using PCB spacers. The electrical connection is made with 14 short wires. Preset P1 is adjusted for optimum legibility of the texts appearing on the display.

While testing, make sure that the directive 'LCD' is included in the 'FORMAT' statement. Also, the command LCDSET is required at the start of the program to enable the LCD to be initialised.

The GoldCap on the board enables the real-time clock to keep operating even if the supply voltage is absent for a few days. The extension board draws only a few milliamps, which goes mainly on account of the LEDs. The printed circuit board shown here is available ready-made through the Publishers. (984028-1)

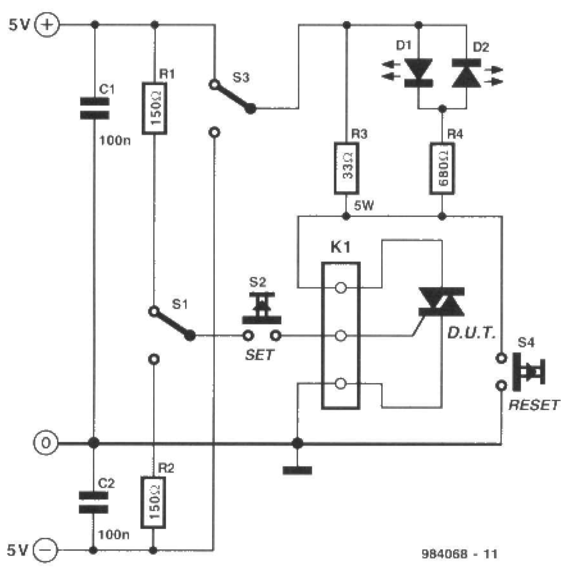
054 thyristor tester

Design: T. Giesberts

The circuit in the diagram is a very handy tool for rapidly checking all kinds of thyristor (SCR, triac, ...). In case of a triac, all four quadrants are tested, which is done with S_3, while in case of a standard thyristor, a positive power supply and trigger current need to be set, which is done with S_1.

The value of resistors R_1 and R_2 is chosen to obtain a current of about 28 mA, which is more than sufficient for most thyristors. The hold current is determined by R_3, and is 125 mA, which is more than adequate to keep the thyristor in conduction after it has been triggered.

Since D_1 is a red, low-current LED, and D_2 a green, low-current LED, it can be seen in a wink in which quadrant the thyristor conducts.



Testing is started with S_2, and the circuit is reset with S_4 after the test has been concluded.

Three short lengths of circuit wire terminated into insulated crocodile clips on connector K_1 will be found very convenient for linking any kind of thyristor to the circuit. Mind correct connections, though: in the case of a triac, MT_1/A_1 is linked to earth, the gate to S_2 and MT_2/A_2 to R_3; in the case of a standard thyristor, the anode is linked to R_3, the cathode to earth, and the gate to S_2.

If, in a rare case the trigger current needs to be altered, this can be done by changing the value of resistors R_1–R_3 as appropriate. The trigger current may also be made variable by the use of a variable power supply. If that is done, make sure that the dissipation in the resistors is not exceeded.

(984068)

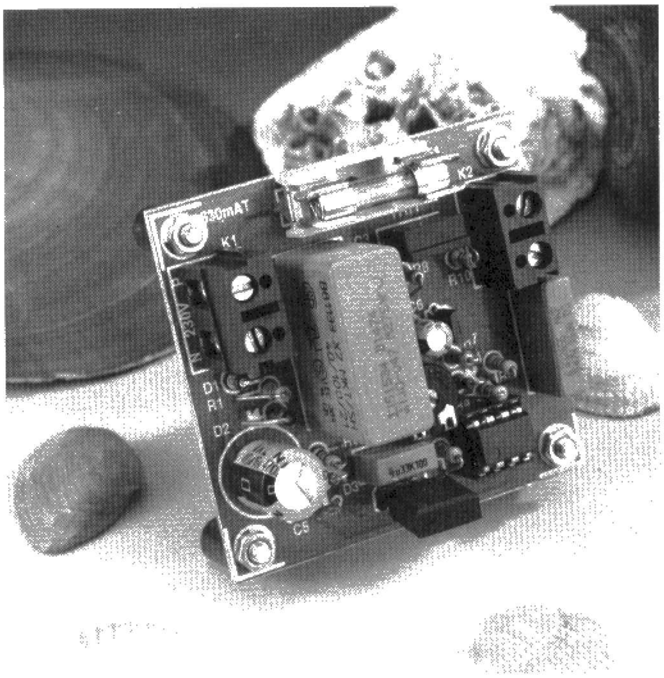
055 automatic air humidifier

Design by H. Bonekamp

The humidifier circuit is based on a special humidity sensor Type NH-3 from Figaro. Depending on the sensor output, the circuit drives a ventilator that is part of an air humidifying installation. The ventilator is switched on an off by a triac.

So as to keep the circuit as simple as possible, the supply voltage and the test voltage are drawn directly from the mains supply. The 240 V mains voltage is converted into an 8.9 V pulsating direct potential by capacitor C_1, resistor R_1 and zener diode D_1. The pulsating voltage is used to drive the sensor. It is also transformed to a 7.5 V supply voltage by D_2 and C_2.

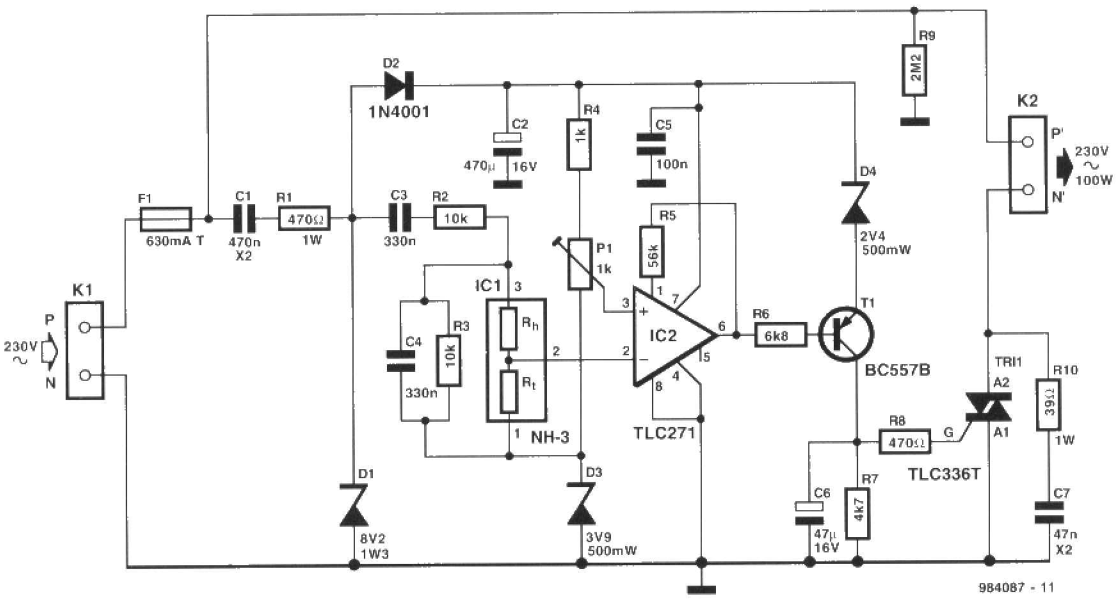
The sensor needs an alternating drive voltage at a level not higher than 1.5 V. This potential

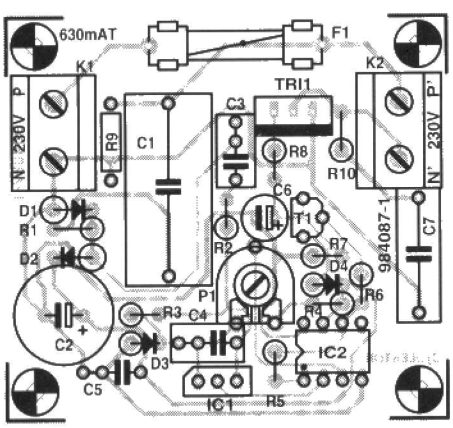


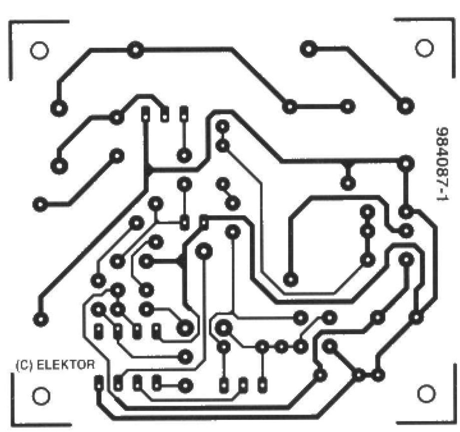
is obtained from the pulsating direct voltage by network R_2-R_3-C_3-C_4, which removes the direct voltage component and lowers the level to 1.4 V. At the same time, the network functions as a 50 Hz bandpass filter.

To ensure that the drive voltage for the sensor does not fall outside the common-mode range of op amp IC_2, an offset potential of 3.9 V is applied to the sensor as well as to the voltage reference source of the op amp. This potential is provided by zener diode D_3. The reference level is set with P_1.The op amp is given some hysteresis by R_5.

When the humidity of the ambient air rises above that corresponding to the level with P_1, the output voltage of IC_2 is about 6 V. This results in T_1 being cut off by D_4, whereupon the triac is also disabled. When







the humidity drops below that corresponding to the level set with P_1, a pulsating potential appears at the output of IC_2. This voltage is used to charge capacitor C_6. The charged capacitor thereupon provides a steady current to the triac.

When T_1 is cut off for some time, capacitor C_6 is discharged via resistor R_7. Capacitors C_1 and C_7 are discharged via R_9, so that after the mains has been switched off, no dangerous potential remains at the pins of the mains connector (K_1).

The humidifier is best built

Parts list

Resistors:
R_1 = 470 Ω, 1 W
R_2, R_3 = 10 kΩ
R_4 = 1 kΩ
R_5 = 56 kΩ
R_6 = 6.8 kΩ
R_7 = 4.7 kΩ
R_8 = 470 Ω
R_9 = 2.2 MΩ
R_{10} = 39 Ω, 1 W
P_1 = 1 kΩ preset

Capacitors:
C_1 = 0.47 μF, 250 V a.c.
C_2 = 470 μF, 16 V, radial
C_3, C_4 = 0.33 μF, metallized polyester, 5%
C_5 = 0.1 μF, high stability
C_6 = 47 μF, 16 V, radial
C_7 = 0.047 μF, 250 V a.c.

Semiconductors:
D_1 = zener diode, 8.2 V, 1.3 W
D_2 = 1N4001
D_3 = zener diode, 3.9 V, 500 mW
D_4 = zener diode, 2.4 V, 500 mW
T_1 = BC557B

Integrated circuits:
IC_1 = NH-3 (Figaro)
IC_2 = TLC271CP
Tri_1 = TLC336T (SGS)

Miscellaneous:
K_1, K_2 = 2-way terminal block for board mounting, pitch 7.5 mm
F_1 = fuseholder with 630 mA slow fuse
PCB Order no. 984087

on the PCB shown in **Figure 2**, which is available ready made (see Readers services pages towards the end of this issue). Bear in mind that parts of the board will carry mains voltage, which makes careful working and the enclosing of the board in a plastic case imperative.

The humidifier may be converted into a dehumidifier by interchanging connections 1 and 3 to sensor IC_1.

[984087]

056 pulse/frequency modulator

Design T. Giesberts

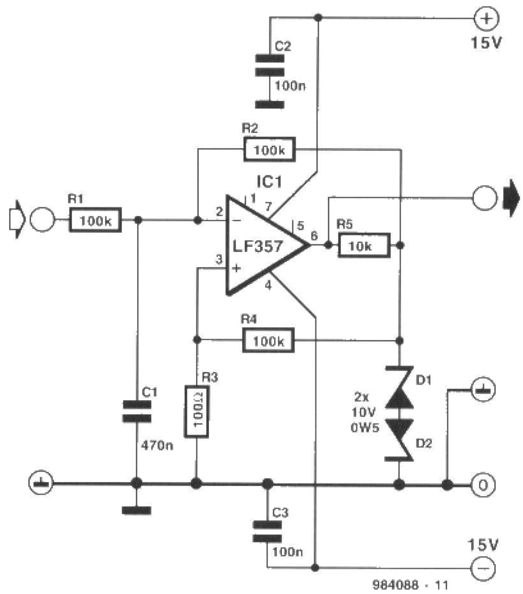
The pulse width of the compact pulse cum frequency modulator can be varied by altering the change-over point of comparator IC_1 with a control voltage via resistor R_1. The hysteresis of the IC is determined by resistors R_3 and R_4. The control voltage also causes the frequency of the present circuit to be altered. When the input voltage is 0 V, the frequency is a maximum: in the present design this is about 3.8 kHz. The level of the output voltage is ±12–13 V.

The more the change-over point has been shifted with the control voltage, the longer it will take before the potential across capacitor C_1 has reached the level at which IC_1 is enabled. When the control voltage is larger than the zener voltage, the oscillator ceases to work. The maximum period is 25 ms, which may be adapted by altering the value of C_1. This will, of course, also alter the maximum frequency.

The duty cycle is inversely proportional to the control voltage. The minimum pulse width attainable at the lowest frequency is about 6 μs.

The modulator draws a current not exceeding 5 mA.

[984088]

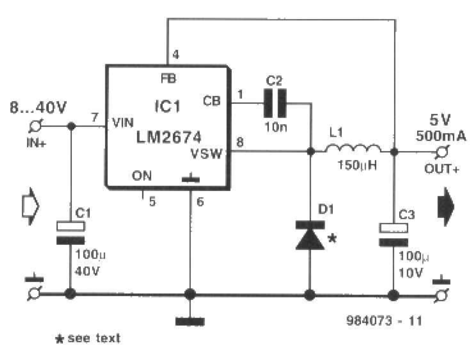


057 switch-mode power supply

A National Semiconductor Application

National Semiconductor has been producing and designing ICs for use in switch-mode power supplies for many years. The application of these devices is normally straightforward, helped by the excellent documentation that is available.

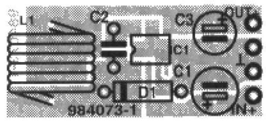
A typical example of a switch-mode power supply is that based on the LM2671 or LM2674. The components for it are available for outputs of 3.3 V, 5 V and 12 V. There is also a version providing a presettable output voltage.



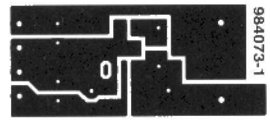
Within the specified application, the supplies can deliver currents of up to 500 mA. Noteworthy is the high switching frequency of 260 kHz. This has the advantage that only low-value inductor and capacitors are needed, and this results in excellent efficiency and small dimensions. In normal circumstances, the efficiency is 90% and may even go up to 96%.

Both ICs provide protection against current and temperature

overloads. The LM2671 has a number of additional facilities such as soft start and the option to work with an external clock. The latter enables several supplies to be synchronized so as to give better control of any EMC (ElectroMagnetic Compatibility).



The application shown in the diagram provides an output voltage of 5 V and an output current



of up to 500 mA. Diode D_1 is a Schottky type ($U_{co} \geq 45$ V and $I_{max} \geq 3$ A).

Additional information on the IC and design software are available from http://www.national.com/sw/SimpleSwitcher/.

[984073]

058 input impedance booster

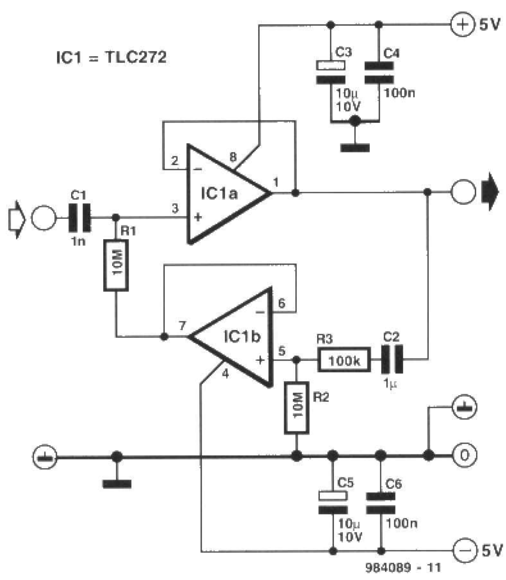
Design H. Bonekamp

The input resistance of a.c.-coupled op amp circuits depends almost entirely on the resistance with which the d.c. setting is determined. If CMOS op amps are used, the input resistance is normally high, currently up to 10 MΩ.

If a higher value is needed, a bootstrap circuit may be used. This enables the input resistance to be boosted artificially to a very high value, indeed

In the circuit shown in the diagram, resistor R_1 sets the d.c. point for IC_{1a}. The terminal of the resistor linked to pin 7 of IC_1 would normally be at earth potential, so that the input impedance would be 10 MΩ.

Connecting the other terminal of the resistor to earth via IC_{1a} and network C_2-R_3-R_2 as



far as d.c. is concerned results in the requisite d.c. setting of the op amp.

As far as alternating voltages are concerned, the input signal is fed back so that only a tiny alternating current flows through R_1. Therefore,

$$R_{in}=R_1[(R_2+R_3)/R_3].$$

With resistor values as specified, R_{in} is about 1 GΩ.

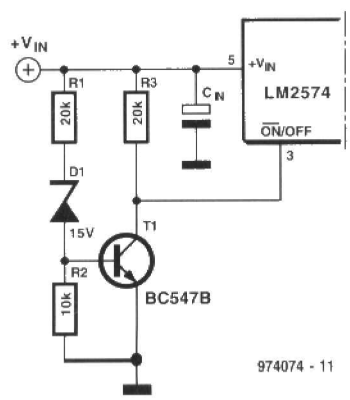
One aspect must be borne in mind: the numerical value of $(R_2+R_3)/R_3$ must not exceed 0.99. This means that the value of R_3 cannot be less than 100 kΩ if the value of R_2 is 10 MΩ. If these conditions are not met, the circuit will become unstable.

[984089]

059 soft start for switching power supply

A National Semiconductor Application

switching power supply whose output voltage is appreciably lower than its input voltage has an interesting property: the current drawn by it is smaller than its output current. However, the input power (UI) is, of course, greater than the output power. There is another aspect that needs to be watched: when the input voltage at switch-on is too low, the regulator will tend to draw the full current. When the supply cannot cope with this, it



fails or the fuse blows. It is, therefore, advisable to disable the regulator at switch-on (via the on/off input), until the relevant capacitor has been charged. When the regulator then starts to draw current, the charging current has already dropped to a level which does not overload the voltage source.

The circuit in the diagram provides an output voltage of 5 V and is supplied by a 24 V source. The regulator need not be disabled until the capacitor is fully charged: when the

potential across the capacitor has reached a level of half or more of the input voltage, all is well. This is why the zener diode in the diagram is rated at 15 V.

Many regulators produced by National Semiconductor have an integral on/off switch, and this is used in the present circuit. The input is intended for TTL signals, and usually consists of a transistor whose base is accessible externally. This means that a higher switching voltage may be applied via a series resistor: the value of this in the present circuit is 22 kΩ. When the voltage across the capacitor reaches a level of about 17 V, transistor T_1 comes on, whereupon the regulator is enabled.

[984074]

060 Infra-red remote control tester

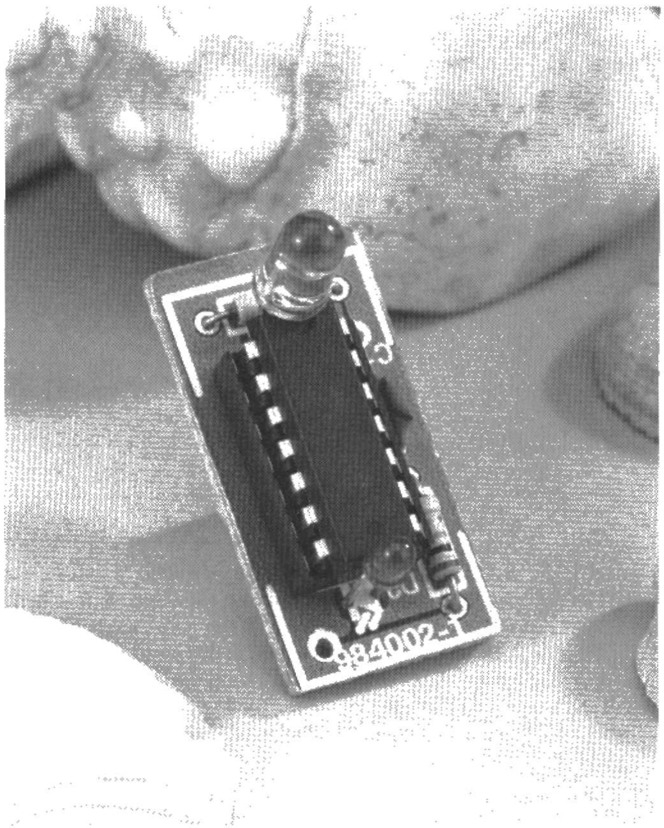
Design: W. Foede

This little circuit is invaluable for quick go/no-go testing of just about any remote control transmitting infra-red (IR) light. The tester is battery-powered, built from just a handful of commonly available and inexpensive parts, and fits in a compact enclosure.

Schmitt trigger gate IC1f is used as a quasi-analogue amplifier with, unusually, an infra-red emitting diode (IRED) type LD274 acting as the sensor element. An R-C network, C1-R2, is used at the output of the gate because all IR remote controls transmit pulse bursts, and to prevent the output LED, D2, lighting constantly when daylight or another continuous source of IR light is detected. This creates a useful 'quick test' option: point the tester at direct daylight, and the indicator LED should light briefly. The sensitivity of the tester is such that IR light from remote control is detected at a distance of up to 50 cm.

The circuit is designed for very low power consumption, drawing less than 1 mA from the battery when IR light is detected, and practically no current when no light is detected. Hence no on/off switch is required. The construction drawing shows how the tester may be 'cased' using a small ABS case from Conrad. Unfortunately, the printed circuit board whose artwork is shown here is not available ready-made.

(984002-1)



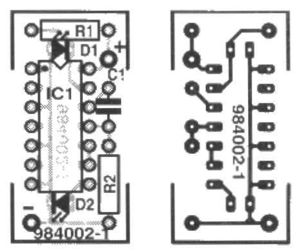
COMPONENTS LIST

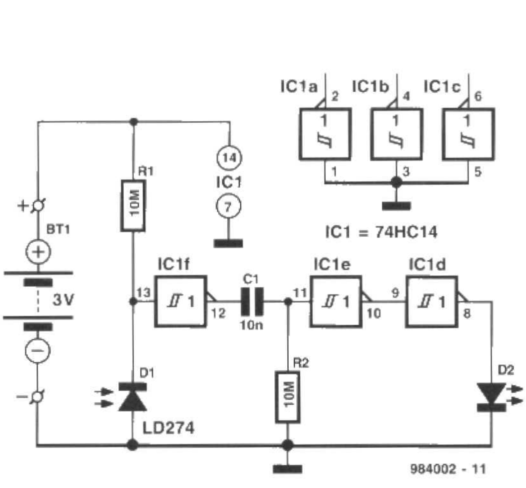
Resistors:
R1,R2 = 10MΩ

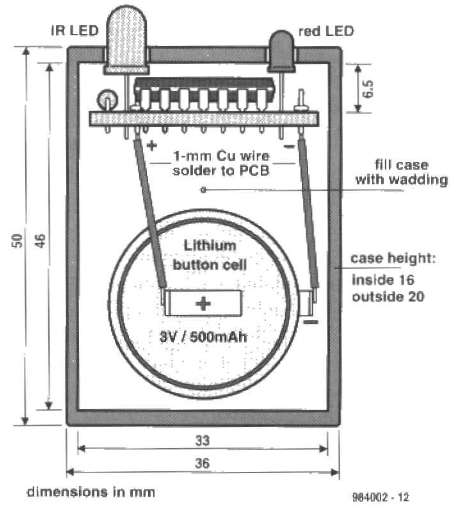
Capacitor:
C1 = 10nF

Semiconductors:
D1 = LD274 (Siemens)
D2 = LED, 3mm, low-current
IC1 = 74HC14

Miscellaneous:
Bt1 = 3V Lithium cell with solder tags, e.g. Varta type CR2045 (560 mAh)
Case, 50x30x13 mm (approx.), Conrad Electronics, order code 52 20 74-44.







061 symmetrical full-wave rectifier

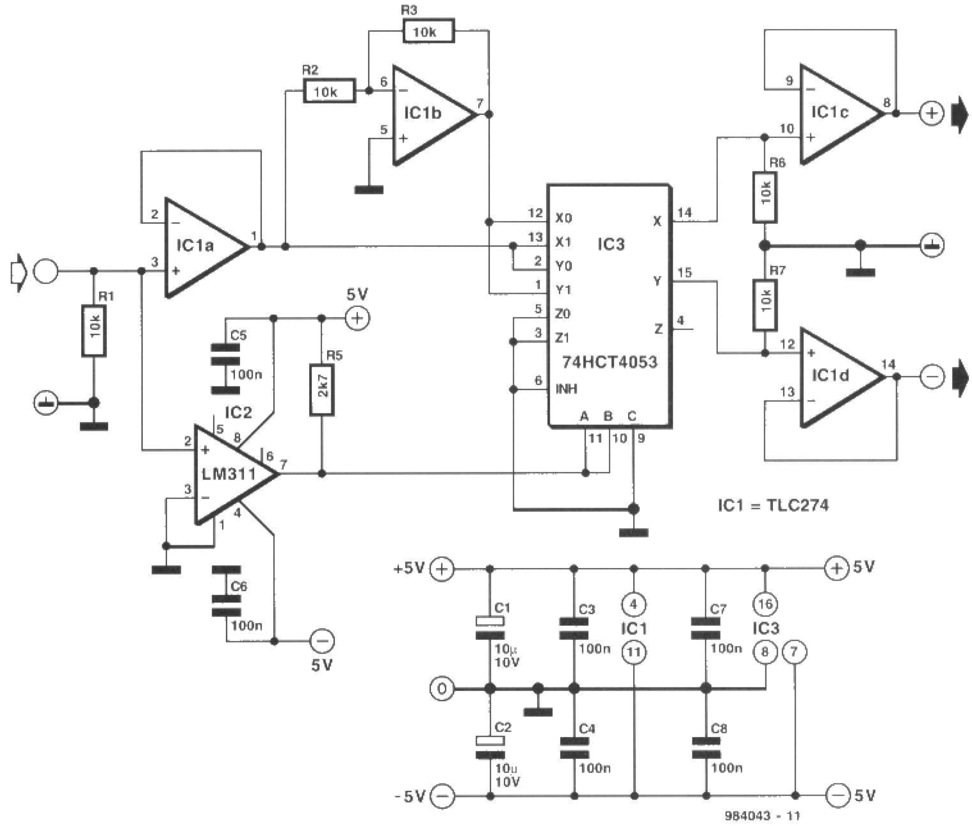
Design: H. Bonekamp

Active rectifiers often consist of an op amp circuit with diodes in the feedback loop. Such traditional arrangements work very well in many applications, but the diodes introduce, by definition, non-linearity. However, the flaw so introduced is compensated adequately if the open-loop amplification of the op amps is sufficiently high. This is well and good at low frequencies, but the open-loop gain of op amps drops appreciably at high frequencies. This results in insufficient compensation of the the non-linearity introduced by the diodes, which gives rise to distortion.

The rectifier presented in this article is free of such problems, since it has no diodes in the signal paths: only linear components.

The circuit is based on analogue multiplexer IC_3 and comparator IC_2. The signal to be rectified is initially buffered by op amp IC_{1a}. From there, it is applied to two inputs of the multiplexer: one in the original state of the signal and the other in inverted form by IC_{1b}. The input signal is also applied to comparator IC_2. The output of this stage will toggle between high and low in the rhythm of the input signal.

On command of the output signal from the comparator applied to its pin 11, the multiplexer switches between the original signal at X_1 and the inverted signal at X_0. This results in a signal at the output of the multiplexer whose polarity no longer varies, but remains constant: the signal is rectified. The user can even choose between the positive voltage at pin 14 and the negative signal at pin 15. The rectified signals are buffered by IC_{1c} and IC_{1d}.



The rectifier operates over a band extending from 0 Hz to 100 kHz.

The rectifier needs a power supply of ±5 V, from which it draws a current of about 6 mA.

[984043]

062 video amplifier

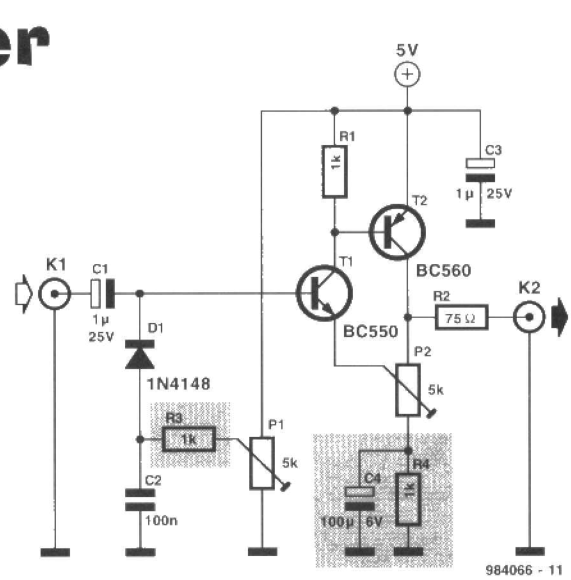
Design: L.A.M. Prins

The video amplifier in the diagram is a well-known design. Simple, yet very useful, were it not for the ease with which the transistors can be damaged if the potentiometers (black level and signal amplitude) are in their extreme position. Fortunately, this can be obviated by the addition of two resistors.

If in the diagram R_3 and R_4 were direct connections, as in the original design, and P_1 were fully clockwise and P_2 fully anticlockwise, such a large base current would flow through T_1 that this transistor would give up the ghost. Moreover, with the wiper of P_2 at earth level, the base current of T_2 would be dangerously high. Resistors R_3 and R_4 are sufficient protection against such mishaps, since they limit the base currents to a level of not more than 5 mA.

Shunt capacitor C_4 prevents R_4 having an adverse effect on the amplification.

[984066]



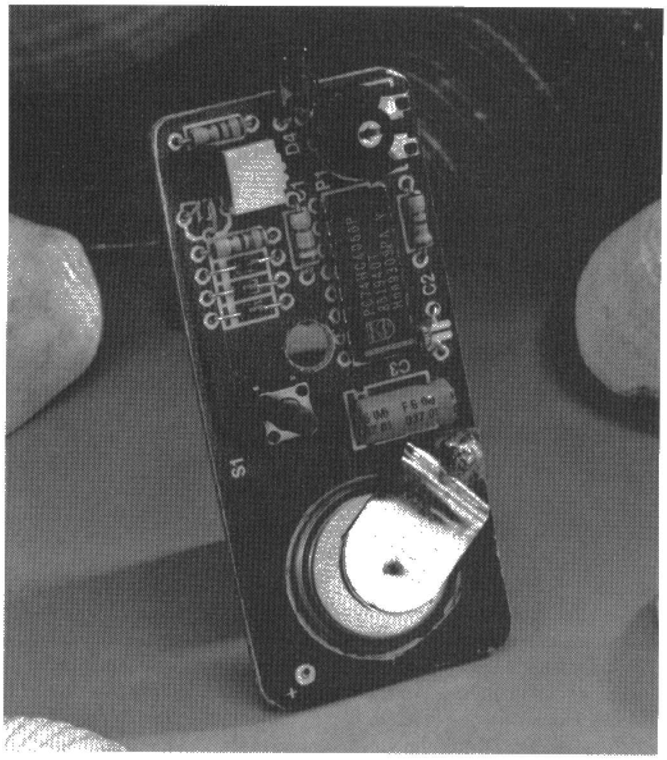
063

simple infrared transmitter

Design: T. Giesberts

This little circuit will be valued highly whenever a signal is required for the testing of infrared receivers. In most cases, such a test is possible without having the associated remote control available. Of course, the test will then be limited to just the infrared sensor device in the receiver, but it's incredibly useful to begin with when it comes to faultfinding in an infrared controlled system like a TV set or a VCR. The combination of this test transmitter and the simple infrared receiver described elsewhere in this issue yields a simple one-channel on/off remote control.

Like a 'real' remote control unit, the present transmitter emits pulses modulated on to a carrier signal of about 36 kHz. Because it not necessary, for the testing purposes outlined above, to have a true encoded pulse train (like RC5, RECS80 *et al.*),



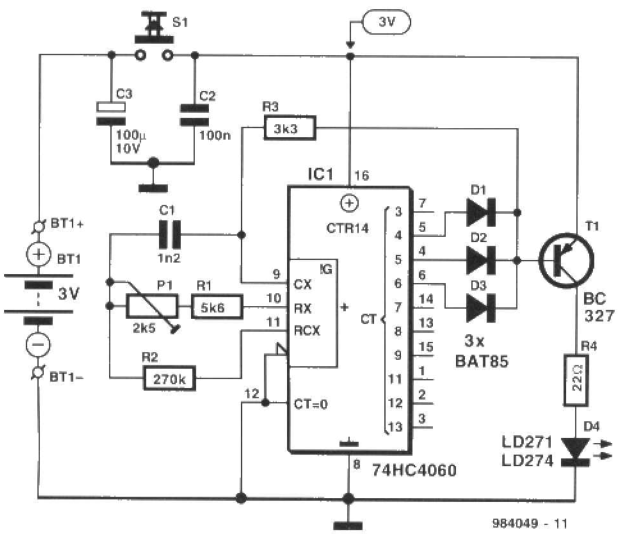
COMPONENTS LIST

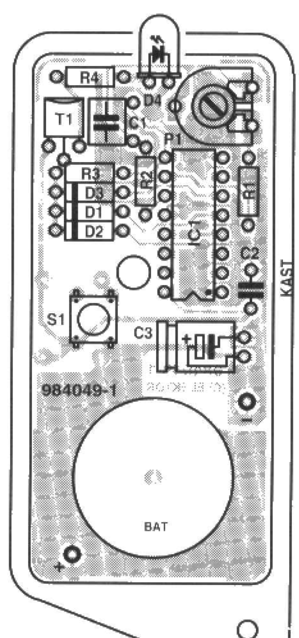
Resistors:
R1 = 5kΩ6
R2 = 270kΩ
R3 = 3kΩ3
R4 = 22Ω
P1 = 2kΩ5 preset, horizontal

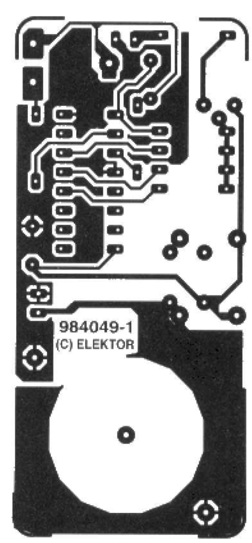
Capacitors:
C1 = 1nF2, raster 5mm
C2 = 100nF, raster 5mm
C3 = 100µF, 10V, radial

Semiconductors:
D1,D2,D3 = BAT85
D4 = LD271 or LD274
T1 = BC327
IC1 = 74HC4060 (Philips, do not use Texas Instruments)

Miscellaneous:
S1 = miniature push-button, e.g., Conrad o/n 70 04 79-44
Bt1 = 3V Lithium button cell, 20mm diameter, e.g. type CR2032 (Varta)
Printed circuit board, order code 984049-1, see Readers Services page.
Case: Nedis type Box UM14







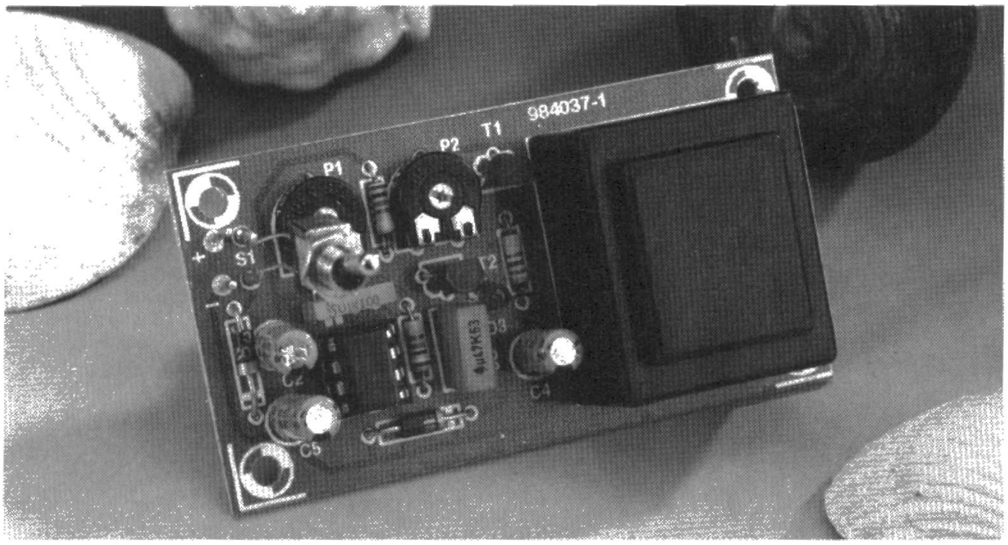
the bursts can be made using three counter outputs connected to a diode triplet, D1, D2-D3, acting as a wired-OR for logic ones. Schottky diodes are used here because of their inherent low forward voltage drop of just 0.4 V. The 14-stage ripple carry counter type 74HC4060 also contains an oscillator which is set up to oscillate at about 36 kHz by means of components R2, P1, R1 and C1. Via resistor R3, the buffered oscillator output at pin 9 supplies carrier (clock) pulses to the driver transistor. If one of the counter outputs is logic high, however, T1 is turned off. In this way, a signal is obtained which, apart from encoding information, resembles that produced by a real remote control unit.

A fast p-n-p switching transistor, T1, is used in common-emitter mode to make sure the circuit keeps transmitting even if the battery is almost 'flat'. In fact, the test transmitter will keep working reliably at 36 kHz at battery voltages down to 1.7 V. Because of the small duty factor of the 60-mA peak-pulse level sent through the LD271 (or LD274) sender diode, the average current drawn from the 3-volt Lithium button cell is moderate at about 6 mA when the battery is full, and 2.5 mA when the battery is drained to 2.5 V. The circuit has a small push-button, S1, which is pressed whenever a test signal is required.

The whole circuit including the battery is conveniently built on the compact PCB whose artwork is shown here. This board is available ready-made through the Publishers, and designed to fit in a special key-fob case from Nedis Electronics.

(984049-1)

064 low-impact muscle stimulator



Used with care, this circuit can provide a small degree of stimulation for muscles. Two electrodes are fixed on the skin covering the muscle area. The distance between the electrodes has to be between 1 cm and about 5 cm. The circuit generates voltage pulses at an adjustable rate of between 0.6 Hz and 4 Hz. The output voltage level is also adjustable between 0 V and 250 V. The highest pulse energy supplied by the circuit is limited to a value of about 0.4 mJ, which is generally believed to be safe.

The TLC555, IC1, is wired in astable multivibrator (AMV) mode. Its output signal frequency is adjustable with preset P1. Transistor T1 and preset P2 form an adjustable voltage source which charges capacitor C4 (via resistor R3) to the voltage level set with P2. Using the capacitor energy expression $[0.5*C*U^2]$, it is found that C4 contains a fairly accurately defined amount of energy which is smaller than or equal to 0.4 mJ. By charging C3 via R3, a simple and safe means is available of limiting the maximum power to be transferred to the muscle. As regards the on-time of the pulses, the output resistance of the TLC555 in combination with the value of C3 cause transistor T2 to conducts just 0.5 ms. During that time, T1 connects the low-voltage winding of Tr1 in parallel with C4, enabling the energy stored in the capacitor to be transferred to the electrodes, and from there, to the muscle tissue. LED D3, finally, indicates the pulse activity. The printed circuit board shown here is unfortunately not available ready-made from the Publishers.

WARNING. Not medically approved to any standard, this circuit should not be used by people suffering from heart ailments or epilepsy. The circuit is generally safe for use on arm and leg muscles, but not for heart stimulation. In case of doubt, see your GP.

(984037-1)

COMPONENTS LIST

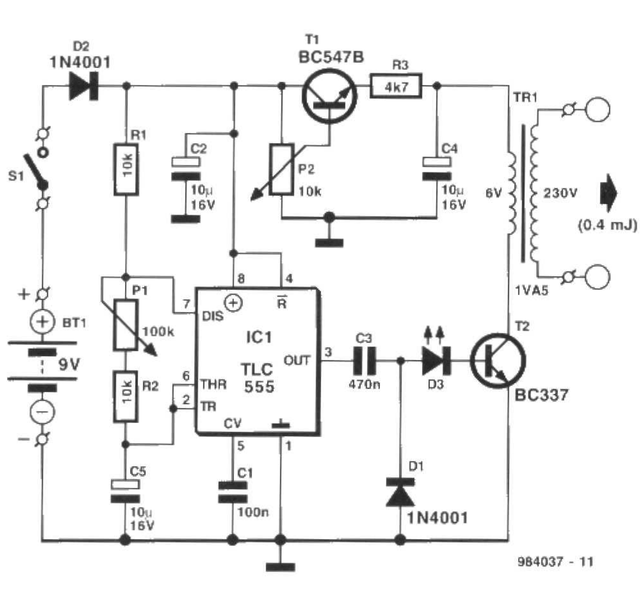
Resistors:
R1,R2 = 10kΩ
R3 = 4kΩ7
P1 = 100kΩ preset H
P2 = 10kΩ preset H

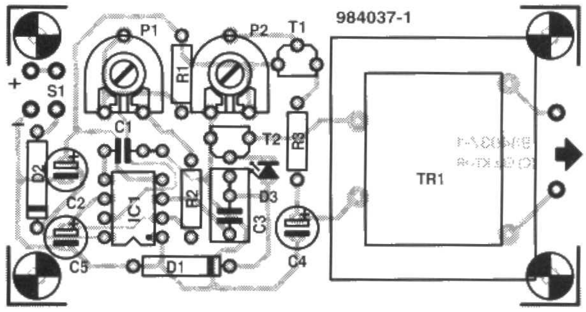
Capacitors:
C1 = 100nF MKT (Siemens)
C2,C4,C5 = 10μF 16V radial
C3 = 470nF MKT (Siemens)

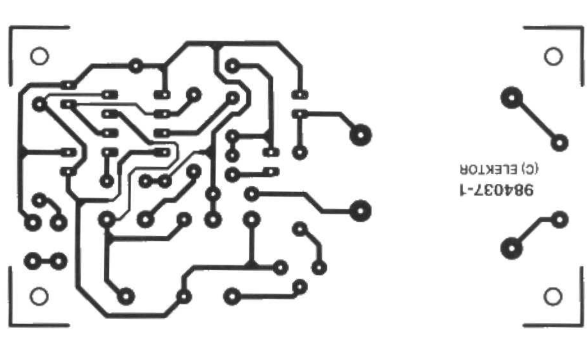
Semiconductors:
D1,D2 = 1N4001
D3 = LED, high efficiency, red
T1 = BC547B
T2 = BC337
IC1 = TLC555CP (must be CMOS type)

Miscellaneous:
Bt1 = 9V PP3 block, with clip-on leads
S1 = on/off switch
Tr1 = mains transformer, 6V, 1.5VA, Monacor/Monarch* type VTR1106

* No UK distributor, item available from C-I Electronics or Stippler Electronics.







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JULY & AUGUST 1998

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- PCB, PIC and disk	960098-C	35.50	71.00
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Hands-On Electronics:			
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NOVEMBER 1996			
ST62 Programmer:			
- PCB and disk	960105-C	16.75	33.50
- PCB only	960105-1	12.75	25.50
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- MicroCap V demo disks	966021-1	4.00	8.00
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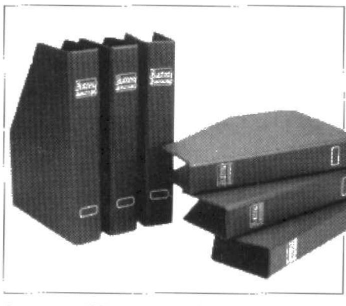
For availability of older items, please contact our Dorchester office.

Elektor Electronics slipcase



Price £2.95 +P&P (see reverse of Order Form).

065 'Ultima' loopstick VLF antenna

Design:
Richard Q. Marris G2BZQ

With its 30 cm long, 3.2 cm diameter (12 x 1¼ inch) 'bundled' ferrite core, the 'Ultima' high-performance loopstick antenna covers much interesting activity between 50 kHz and 195 kHz. The 'Ultima' is ideal for home, portable, holiday and overseas travel. It also covers the new 136 kHz band with excellent results, but for *reception only*.

An increasing number of radio amateurs in the UK and several European mainland counties are now actively using a new VLF (Very Low Frequency) band at 136 kHz (135.7 – 137.8 kHz). The big challenge at these extremely long wavelengths is to make transmitter antennas with reasonable *efficiency*. In fact, anything greater than 1 per cent is considered a feat! As to receiver antennas, the emphasis is on *noise elimination*. Recently, distances of almost 2,000 km have been covered by amateurs using CW and modest transmitter powers (EI0CF – OH1TN, 2-way CW QSO on 137.2 kHz). To amateurs in the UK, the station DA0LF in Germany is a good 'DX target'. Lots of useful information on VLF Dx-ing may be found in *RadCom*, the magazine published by the Radio Society of Great Britain (RSGB). In the US, a group calling themselves 'Lowfers' has been active for many years collecting valuable information on the quirks of 'their' 1,750-metre band.

The 'feel' of the radio spectrum below 150 kHz or so (approx. 2,000 metres) is totally different from anything you may have experienced on higher frequencies. Although you will not fail to notice a complete lack of AM broadcast stations, the most prominent feature is the huge noise level which can, on occasion, have a devastating effect on reception.

For reception, a specially-designed type of receiving antenna will be found desirable, especially in urban areas where levels of man-made noise can be diabolical, especially when using a long-wire antenna. Noise experienced below about 150 kHz is either internal or external. *Internal noise* is either generated in the receiver, or enters via the AC mains power wiring. Remedial action can be taken. *External noise* is different kettle of fish. Entering by way of the antenna, it is either man-made or atmospheric. Man-made noise, in its simplest forms, is QRM from another station. Otherwise, especially in urban areas, man-made noise can be from just about any electrical/electronic source such as TVs, computers, calculators, thermostats, light dimmers, vacuum cleaners, lawn mowers, electric power tools, traffic, power lines and may other sources in the immediate neighbourhood. Atmospheric noise, including electric storms, is a natural phenomenon, which, at its worst, can obliterate reception.

Space to many amateurs is at a premium, and a multi-turn tuned frame loop antenna of, say, 1.2 m x 1.2 m will be the absolute size limit. Despite all its obvious advantages, including sensitivity and good selectivity, such a directional antenna can be a cumbersome brute, and inconvenient to store when not

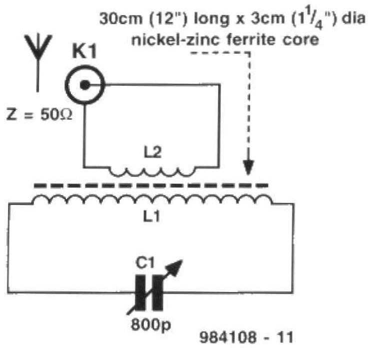


Figure 1. Schematic of the Ultima ferrite-rod VLF antenna

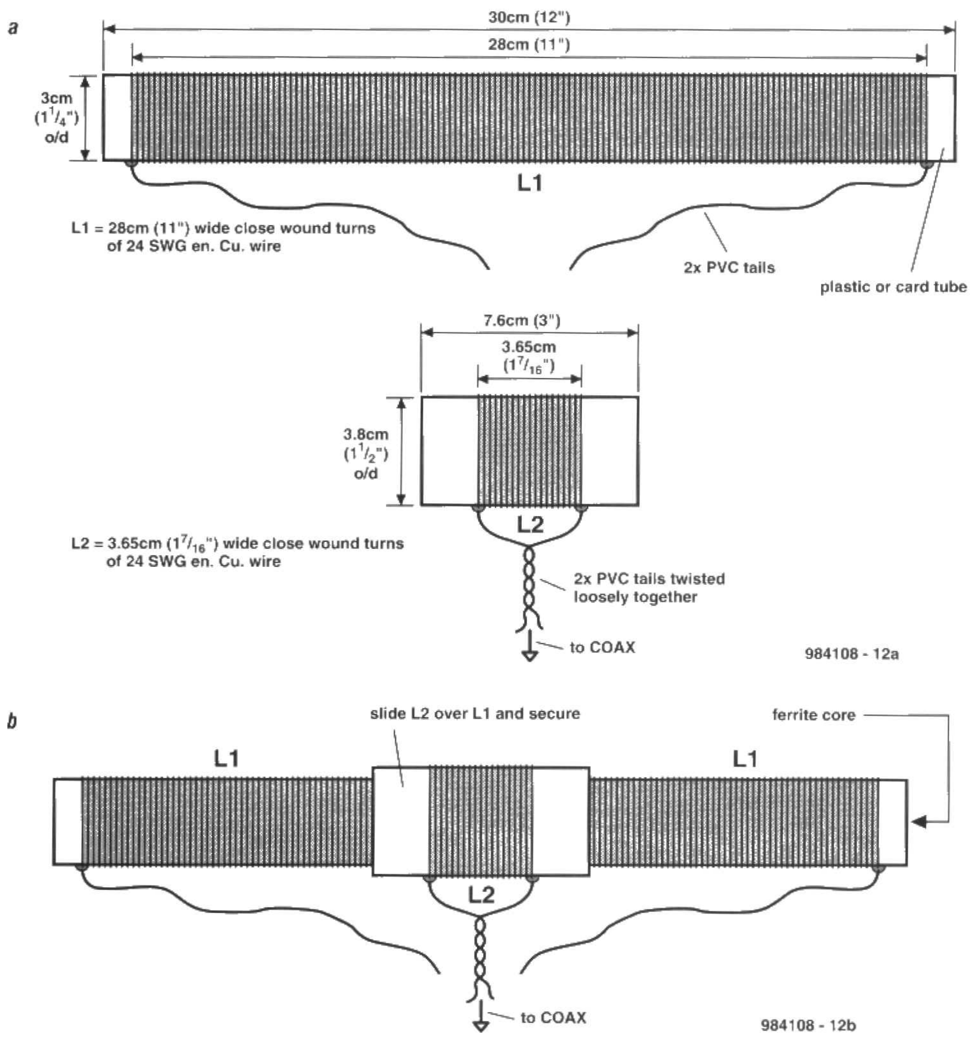


Figure 2. (a) winding L1 and L2; (b) L1 and L2 assembly.

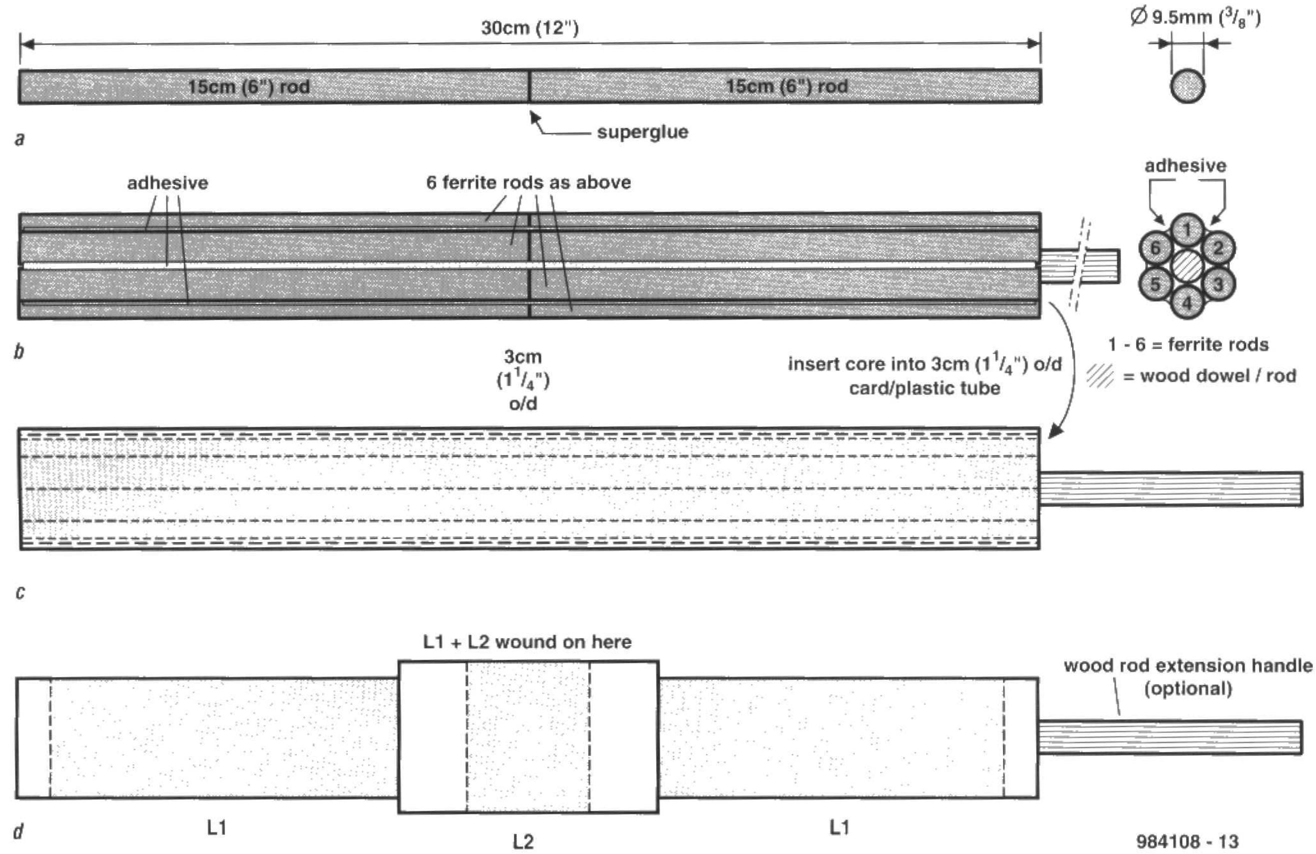


Figure 3. Build the Ultima in this order. Forming a single 30 x 1 cm (a); and a single 30 x 3.2 cm ferrite core (b). Drawing (c) shows the 30 x 3.2 cm ferrite winding assembly, and drawing (d) the format of the final ferrite core.

in use.

An alternative is a ferrite-rod loop ('loopstick'), which in its original form is less sensitive than a frame loop. However a highly sensitive ferrite loop can be designed with careful selection of ferrite core materials and dimensions. To put it simply, the ferrite loop then has to be *large* at, say, 30 x 2.5 cm (12 x 1 inch). Unfortunately, such ferrite rods are not only few and far between but also astronomically expensive. The size of affordable manganese-zinc or nickel-zinc ferrite rods stocked by radio parts retailers is usually either 20 x 1 cm (8 x ⅜ inch) or 20 x 1.25 cm (8 x ½ inch). It was decided to home-brew a 30 cm long, 3.2 cm diameter (12 x 1¼ inch) rod by bundling a number of smaller zinc-nickel rods. The target inductance was 26+ mH.

In the basic loopstick circuit shown in **Figure 1**, coil L1 is brought to resonance by variable capacitor C1. The core of L1 is the above mentioned 'bundled' giant loopstick. Over the centre of L1 is wound coupling coil L2, which provides the coaxial connection to the receiver or VLF up-converter. The coil assembly (Figure 2) is wound on a 30 cm long x 3.2 cm diameter thin wall cardboard tube (Clingfilm tubing!). L1 has a width of 28 cm, and consists of an estimated 466 close-wound turns of 24 SWG (0.6 mm) enamelled copper wire (**Figure 2a**). The winding is terminated with lead-outs of PVC covered hook-up wire. In practice the winding ends were held in place with a spot of SuperGlue, with other spots every 2.5 cm or so along the winding. This is necessary as winding the coil is a lengthy process. The coupling coil, L2, is wound on a 7.6-cm (3-inch) length of cardboard tube of a diameter which just slips over L1. L2 is a 3.6-cm (1 7/16 inch) wide close-wound winding of 24 SWG enamelled copper wire, terminated with hook-up wire leads lightly twisted together. The whole coil assembly is shown in **Figure 2b**.

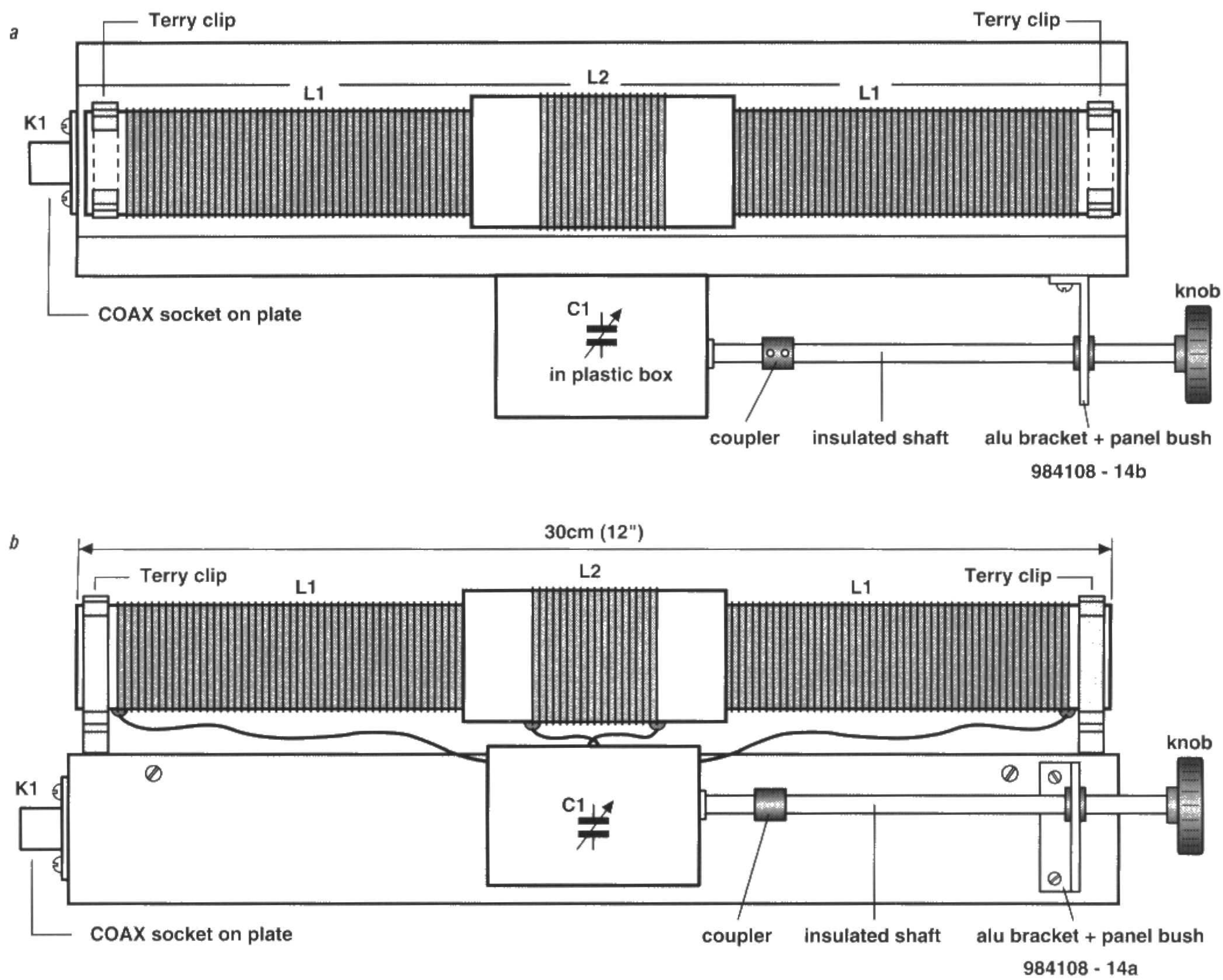
The next step is to build the bundled ferrite core — this is illustrated in **Figure 3**. It consists of six 30 cm long, 1 cm diameter ferrite rods glued together to form one solid 30 cm x 3.2 cm (approx.) core. MMG F14 grade nickel-zinc material was used. An alternative would be the US type 61 material. At these low frequencies, the difference in performance between the F14 and 61 materials is small. Each 30-cm rod is made from two 15-cm rods, secured end-to-end with SuperGlue. The rod ends should first be lightly rubbed down with a fine glass paper in order to remove any grease, etc. (see **Figure 3a**). This technique effectively produces one long rod from two shorter ones. Other combinations of length could be used such as 20 + 10 cm, the 10-cm section being cut from a 20-cm rod using a hacksaw. In this way, three 20-cm rods would make two 30-cm rods.

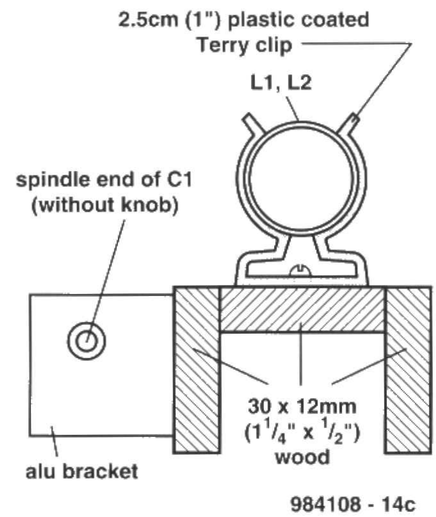
The solid 30-cm long, 3.2 cm diameter ferrite rod consists of six 30-cm rods wrapped around a wood dowel, and temporarily held in position with a couple of elastic bands, see **Figures 3b, 3c and 3d**. Next, the rods and dowel are adhered together to form one solid core, by cementation with a 15-minute setting adhesive such as Uhu. The adhesive is run along between all mating rod and dowel surfaces, by easing them gently apart with a thin blade. It is important to ensure that the surfaces have the adhesive between them. Several strong elastic bands are put around the rods, making sure that the circular rod formation is maintained. The assembly should be left in a warm place for at least 24 hours to make sure that the adhesive is thoroughly cured. The elastic bands are then cut away.

The core is then inserted into L1, with any slight looseness being eliminated with masking tape. On the prototype, the wood dowel was made a few centimetres longer than the rods, so that the core can be extracted from the coil if and when necessary, for example, for experiments.

The simple final assembly is clearly shown in **Figures 4a, 4b and 4c**. Three identical strips of wood are fastened together with wood screws to form an inverted 'U' shape chassis. Coil L1/L2 is mounted on the top with two narrow type plastic coated Terry clips fastened at the chassis ends. The twisted ends of L2 are dropped through a hole drilled in the chassis top, and taken to the coaxial socket mounted on a piece of thin board, screwed to the chassis end.

The 800-pF tuning capacitor, C1, is mounted on the chassis side as shown in Figure 4. On the prototype, a rigid air-spaced 800-P tuning capacitor (392+11+392+11 pF AM/FM





COMPONENTS LIST

12 off F14 or 61 grade ferrite rods, 15 cm long, 1 cm diameter (6 x ⅜ inch)
1 off 3.2 cm (1 ¼ inch) thin wall cardboard tube (e.g., Clingfilm tubing)
SuperGlue
Slow setting glue, e.g. Uhu
1 off 800pF tuning capacitor (see text) with shaft coupler, insulated extension shaft, metal bracket, panel bush and knob
1 off 38 cm (15 inch) length of 1 cm (⅜ inch) o/d wood dowel
1 off coaxial socket
2 off narrow 2.5-cm (1 inch) plastic coated Terry clips
Reel of 24 SWG (0.6 mm) enamelled copper wire.

Figure 4. Details of the final assembly.

type wired in parallel) is attached to the chassis side. It is fitted with a shaft coupler and an insulated shaft passing through a panel bush in a small bracket to the control knob. A 1,000-pF (500 + 500 pF) tuning capacitor would also be satisfactory. The tuning capacitor is enclosed in a plastic dust-cover box. The ends of L1 are taken to the tuning capacitor connections.

The tuning range of the prototype was 50 kHz to 195 kHz. The 'Ultima' is used with a Palomar VLF up-converter whose output frequency is in the 80-m (3.5-MHz) amateur radio band. A simple turntable is an advantage to be able to turn the loop, which is directional. The frequency range was carefully selected. At the LF end is the 60 kHz MSF Rugby Standard Time/Frequency station, which produces a mighty signal as might be expected. Moving up-frequency the tuning range passes through the 73-kHz band where various Time/Frequency Standard stations can be received, and much else of interest. Next comes the 2,000-m European Amateur band around 136 kHz which has recently arrived.

As compared with a traditional 20 x 1.25 cm diameter loop-stick, the 'Ultima' features dramatically increased signal strength, with atmospheric and man-made noise being mostly eliminated, or reduced to an acceptable level by simple loop rotation.

(984108-1;W)